ZXR10 5900/5200 Series
All Gigabit-Port Intelligent Routing Switch
User Manual (IPv4 Routing Volume)

Version 2.8.23.A

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About This Manual i
Static Route Configuration 1
Static Route Overview 1
Configuring Static Route 1
Static Route Configuration Example 2
Static Route Configuration Example 2
Static Route Summary Example 3
Default Route Configuration Example 4
Static Route Maintenance and Diagnosis 5
RIP Configuration 7
RIP Overview 7
RIP Basics 7
RIP Routing Metric 7
RIP Timer 8
Route Updates 8
Configuring RIP 9
Enabling RIP 9
Adjusting RIP Timer 9
Configuring RIP Neighbor 9
Configuring RIP Authentication 9
Configuring split horizon mechanism 10
Configuring Poison Reverse Mechanism 10
Redistributing a Route 10
Configuring RIP Version 10
RIP Configuration Example 10
RIP Maintenance and Diagnosis 11
OSPF Configuration 13
OSPF Overview 13
OSPF Basics 13
OSPF Algorithm 14
OSPF Network Types 14
Hello Packet and Timer 15

OSPF Neighbor 15
Adjacency and Designated Routers 15
Router Priority and DR Election 16
OSPF Area 16
LSA Type and Flooding 17
Stub Area and Totally Stub Area 18
Not-So-Stubby Area 18
OSPF Authentication 19
Configuring OSPF 19
Enabling OSPF 19
Configuring Interface Timer 19
Configuring Interface Cost 20
Configuring Interface Priority 20
Configuring Neighbor Routers 20
Configuring OSPF Area 20
Configuring Inter-Area Route Aggregation 20
Notifying Default Route 21
Configuring Virtual Link 21
Redistributing Other Routing Protocols 22
Configuring OSPF Authentication 22
Enabling Routes to Support Opaque LSA 22
Modifying OSPF Management Distance 23
OSPF Configuration Example 23
Basic OSPF Configuration Example 23
Multi-Area OSPF Configuration Example 24
OSPF Virtual Links Configuration Example 25
OSPF Authentication Configuration Example 27
OSPF Maintenance and Diagnosis 30
IS-IS Configuration 33
IS-IS Overview 33
IS-IS Overview 33
IS-IS Area 34
IS-IS Network Type 35
DIS and Router Priority 35
Configuring IS-IS 36
Enabling IS-IS 36
Configuring IS-IS Global Parameters 36
Configuring IS-IS Interface Parameters 37
Configuring IS-IS Authentication 37
IS-IS Configuration Example 38

Single Area IS-IS Configuration 38
Multiple Area IS-IS Configuration 40
IS-IS Maintenance and Diagnosis.....................................42
BGP Configuration 45
BGP Overview 45
Configuring BGP 46
Enabling BGP 46
Configuring BGP Route Advertisement 48
Configuring BGP Aggregate Advertisement 48
Configuring Multihop in EBGP 50
Filtering Routes by Router..51
Filtering Routes Using NLRI..51
Filtering Route Based on AS_PATH 52
Setting LOCAL_PREF Attribute 53
Setting MED Attribute 54
Setting Community Attribute..56
Setting BGP Synchronization 56
Setting BGP Router Reflector..58
Setting BGP Confederation...59
Setting BGP Route Dampening 60
BGP Configuration Example...61
BGP Maintenance and Diagnosis 63
Multicast Routing Configuration 65
Multicast Overview 65
Multicast Address 66
IGMP 66
Multicast Tree 66
PIM-SM 67
MSDP...68
PIM-SNOOPING 69
Configuring Public Multicast 69
Configuring IGMP Version 69
Configuring IGMP Version 69
Configuring an IGMP Group..70
Configuring IGMP Timer..71
Configuring ssm-mapping 72
Configuring PIM-SM 72
Booting PIM-SM..72
Configuring Static RP Address 72
Configuring Candidate-BSR 73

Configure the Candidate-RP 73
Switching Routers with Directly Connected Receivers 73
Configuring the Area Border with the Interface PIM 74
Setting the RP to Filter the Received Register Packet.. 74
Limiting the BSR Message to Advertise to the Candidate-RP 74
Setting DR Priority 75
Setting the Sending Interval of the Hello Message.......... 75
Limiting PIM-SM Neighbor.. 75
Configuring MSDP.. 76
Enabling MSDP.. 76
Configuring Default MSDP Peer 76
Configuring an Originating RP..................................... 76
Configuring the MSDP Peer as a Mesh Group Member 76
Clearing Statistics Counter for MSDP Peers.................... 77
Clearing Statistics Counter for MSDP Peers.................... 77
Clearing Statistics Counter for MSDP Peers.................... 77
Clearing Statistics Counter for MSDP Peers.................... 77
Clearing Statistics Counter for MSDP Peers.................... 78
Configuring PIM-DM 78
Configuring PIM-SNOOPING 78
Multicast Configuration Example 78
Multicast Maintenance and Diagnosis................................ 80
Load Balance Configuration 87
Load Balance Overview 87
Configuring Load Balance 88
Load Balance Configuration Example 88
Static Routing Load Balance 88
OSPF Load Balance 90
BGP Load Balance... 90
Load Balance Maintenance and Diagnosis.......................... 91
Figures 93
Tables 95
Glossary 97

About This Manual

Purpose

ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch User Manual (IPv4 Routing Volume) provides procedures and guidelines that support the operation on ZXR10 5900/5200 Series All Gigabit-Port Intelligent Routing Switch, including:

- ZXR10 5924 Gigabit Routing Switch
- ZXR10 5928 Gigabit Routing Switch
- ZXR10 5928–Fi Gigabit Routing Switch
- ZXR10 5952 Gigabit Routing Switch
- ZXR10 5224 Gigabit Convergence Switch
- ZXR10 5228 Gigabit Convergence Switch
- ZXR10 5228–FI Gigabit Convergence Switch
- ZXR10 5252 Gigabit Convergence Switch
- ZXR10 5928–PS Gigabit Convergence Switch

Intended Audience

This manual is intended for engineers and technicians who perform operation activities on ZXR10 5900/5200 All Gigabit-Port Intelligent Routing Switches.

Prerequisite Skill and Knowledge

To use the IPv4 Routing volume effectively, users should have a general understanding of OSI Model. Familiarity with the following is helpful,

- Protocols
- Routing concepts and Data Communication Terminologies

What Is in This Manual

The IPv4 Routing volume contains the following chapters:

TABLE 1 CHAPTER SUMMARY

Chapter	Summary
Chapter 1 Static Route Configuration	This chapter describes static route and its configuration, including special summary static route.
Chapter 2 RIP Configuration	This chapter describes Routing Information Protocol (RIP) configuration.
Chapter 3 OSPF Configuration	This chapter describes Open Shortest Path First (OSPF) protocol and related configuration.
Chapter 4 IS-IS Configuration	This chapter describes IS-IS protocol and related configuration.
Chapter 5 BGP Configuration	This chapter describes Border Gateway Protocol (BGP) and related configuration.

Chapter	Summary
Chapter 6 Multicast Routing Configuration	This chapter describes Multicast Routing and related configuration.
Chapter 7 Load Balance Configuration	This chapter describes Load Balance and related configuration.

Related Documentation

The following documentation is related to this manual:

- ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch Hardware Manual
- ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch User Manual (Ethernet Switching Volume)
- ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch User Manual (Basic Configuration Volume)
- ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch User Manual (IPv4 Routing Volume)
- ZXR10 5900/5200(V2.8.23.A) Series All Gigabit-Port Intelligent Routing Switch User Manual (IPv6 Routing Volume)
- ZXR10 Router-Ethernet Switch Command Manual - Command Index
- ZXR10 Router-Ethernet Switch Command Manual - System Management
- ZXR10 Router-Ethernet Switch Command Manual - Functional System I
- ZXR10 Router-Ethernet Switch Command Manual - Functional System Volume II
- ZXR10 Router-Ethernet Switch Command Manual - Functional System Volume III
- ZXR10 Router/Ethernet Switch Command Manual — Functional System IV
- ZXR10 Router/Ethernet Switch Command Manual — Protocol Stack I
- ZXR10 Router/Ethernet Switch Command Manual — Protocol Stack II
- ZXR10 Router/Ethernet Switch Command Manual — Protocol Stack III
- ZXR10 Router/Ethernet Switch Information Manual

Chapter 1

Static Route Configuration

Table of Contents

Static Route Overview 1
Configuring Static Route 1
Static Route Configuration Example 2
Static Route Maintenance and Diagnosis 5

Static Route Overview

Static routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. They are useful for specifying a gateway of last resort to which, all-unroutable packets will be sent. The static route, unlike a dynamic route, does not set up the routing table based on routing algorithm. When configuring dynamic route, sometimes it is necessary to send routing information of the entire Internet to a router, which is hard to bear such great amount of information. In this cast, it is necessary to use static route.

The static route requires fewer configurations than the dynamic route. In a routing environment with many routers and paths, however, it is very difficult to configure the static route.

Configuring Static Route

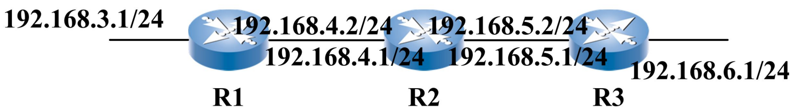
Command	Function
`ZXR10(config)#`**ip route** *<prefix><net-mask>*{*<forwarding-router's-address>*|*<interface-name>*}[global[*<distance-metric>*][**tag** *<tag>*]]	This configures static route.

Static Route Configuration Example

Static Route Configuration Example

A simple network with three routers connected is shown in Figure 1Figure 70.

FIGURE 1 STATIC ROUTE CONFIGURATION



When R1 needs to access network in R3, the static route configuration is as follows.

```
ZXR10_R1(config)#ip route 192.168.5.0 255.255.255.0
192.168.4.2
ZXR10_R1(config)#ip route 192.168.6.0 255.255.255.0
192.168.4.2
```

R2 configuration:

```
ZXR10_R2(config)#ip route 192.168.6.0 255.255.255.0 192.168.5.1
ZXR10_R2(config)#ip route 192.168.3.0 255.255.255.0 192.168.4.2
```

R3 configuration:

```
ZXR10_R3(config)#ip route 192.168.3.0 255.255.255.0 192.168.5.2
ZXR10_R3(config)#ip route 192.168.4.0 255.255.255.0 192.168.5.2
```

It is seen from the above configuration information that static route is configured in global configuration mode. Only one static route can be configured once. What next to the command **ip route** are remote network, subnet mask and next-hop IP address reaching remote network. When R1 wants to transmit message to network 192.168.5.0/24, it must deliver the message to R2 with the IP address of 192.168.4.2; R1 and R2 are connected directly.

When multiple paths to the same destination are available, configure the router with multiple static routes with different administrative distance values. Routing table only shows the routing information with the minimum distance value. When the router is notified that there are multiple competitive sources to a network, the route with the minimum administrative distance value has a higher priority. Parameter **<***distance-metric***>** in **ip route** command can be used to change the administrative distance value of a static route. Assume that there are two different routes from R1 to 192.168.6.0/24 network segment, and the configuration is as follows:

```
ZXR10_R1(config)#ip route 192.168.6.0 255.255.255.0
 192.168.4.2
ZXR10_R1(config)#ip route 192.168.6.0 255.255.255.0
192.168.3.2 25 tag 150
```

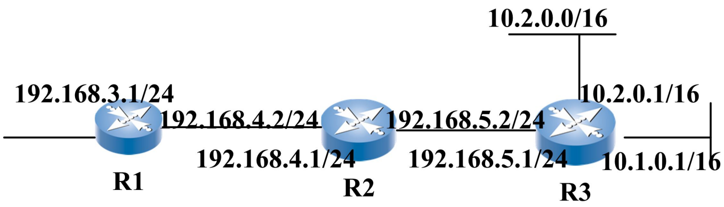
The above two commands configure two different static routes to the same network. The first command does not configure administrative distance value, so default value 1 is applied. The second command configures the administrative distance value to be 25.

The administrative distance value of the first route is smaller than that of the second one, so only the information of the first route is available in the routing table. That is to say, the router reaches the destination network 192.168.6.0/24 through next-hop 192.168.4.2. The second route will be available in the routing table only when the first route becomes invalid and disappears from the routing table.

Static Route Summary Example

Static route is a special static route which summaries two or more specific route expressions into one expression thus reducing entries of the routing table while keeping all of the original connections. Summary static route detail is given in Figure 2.

FIGURE 2 STATIC ROUTE SUMMARY



As shown in Figure 2, R3 has two networks: 10.1.0.0/16 and 10.2.0.0/16. To make R1 access these networks, it is necessary to configure the following two static routes for R1:

```
ZXR10_R1(config)#ip route 10.1.0.0 255.255.0.0
192.168.4.2
ZXR10_R1(config)#ip route 10.2.0.0 255.255.0.0
192.168.4.2
```

Suppose that R2, R3 has been configured normally, and the above configuration can be used to complete IP connection. However, static route summary can be used to optimize the routing table of R1. The following command can be used to replace the above two commands:

```
ZXR10_R1(config)#ip route 10.0.0.0 255.0.0.0 192.168.4.2
```

The above command shows that all packets to destination network 10.0.0.0/8 pass 192.168.4.2. It means that packets to subnets (subnet 10.1.0.0/16 and subnet 10.2.0.0/16) of the destination network 10.0.0.0/8 are sent to 192.168.4.2. In this way static routes are used to summarize all subnets of the main network 10.0.0.0/8.

Default Route Configuration Example

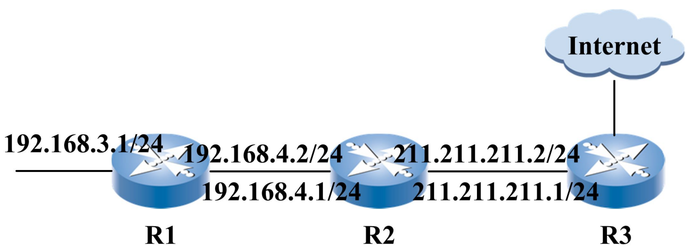
A router might not be able to determine the routes to all other networks. To provide complete routing capability, the common practice is to use some routers as smart routers and give the remaining routers default routes to the smart router. (Smart routers have routing table information for the entire internet work.) These default routes can be passed along dynamically and can be configured into individual routers.

Most dynamic interior routing protocols include a mechanism for causing a smart router to generate dynamic default information that is then passed along to other routers.

If a router cannot route a packet, the packet has to be dropped. However, it is not hoped that the packet is dropped in an "unknown" destination. To support complete connection of the router, it should have a route connected to a network. If the router wants to keep complete connection and meanwhile does not need to record each independent route, the default route can be used. By use of the default route, an independent route can be designated to indicate all the other routes.

An example is given in the following to describe the functions and use of the default route.

FIGURE 3 DEFAULT ROUTE CONFIGURATION



As shown in Figure 3. R2 is connected to router R3 in the Internet. R2 does not record the addresses of all the networks on the Internet. It uses a default route to directly send unknown packets to R3 for proper processing. The configuration of the default route in R2 is as follows:

```
ZXR10_R2(config)#ip route 0.0.0.0 0.0.0.0 211.211.211.2
```

When the default route is used in routing protocol configuration, the default route varies with the routing protocols.

If the default route is configured for a router where an RIP runs, the RIP will advertise the default route 0.0.0.0/0 to its neighbor, and even route redistribution is not needed in the RIP domain.

For the OSPF protocol, a router where the OSPF protocol runs will not inject the default route into its neighbor automatically. For the OSPF to send the default route to the OSPF domain command notifies default route must be used. If it is necessary to redistribute the default route in the OSPF domain, such an advertisement is normally implemented by an ASBR (Autonomous System Border Router) in the OSPF domain.

The default route configuration is completely the same as the static route configuration, and the only difference is that the network part and subnet mask part are all 0.0.0.0. This can be seen in routing table of R2.

```
ZXR10_R2#show ip route
IPv4 Routing Table:
Dest           Mask            Gw        Interface Owner pri metric
0.0.0.0          0.0.0.0      211.211.211.2 vlan1     static 1    0
192.168.4.0  255.255.255.0   192.168.4.2 vlan2     direct0     0
192.168.4.2  255.255.255.255 192.168.4.2 vlan2     address0    0
```

Static Route Maintenance and Diagnosis

Step	Command	Function
1	ZXR10#**show ip route** [<*ip-address*>[<*net-mask*>]|<*protocol*>]	This shows global routing table of the route and checks if there is any configured static route in the routing table.
2	ZXR10#**show ip forwarding** {**hostrt** <*ip-address*>| **subnetrt** <*ip-address*><*net-mask*>| **summary**}	This views hardware routing table and checks host route and subnet route of specific IP address and statistics of subnet route entry and all hosts.

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Chapter 2

RIP Configuration

Table of Contents

RIP Overview 7
Configuring RIP 9
RIP Configuration Example..10
RIP Maintenance and Diagnosis 11

RIP Overview

RIP Basics

RIP is a relatively old but still commonly used interior gateway protocol created for use in small, homogeneous networks. It is a classical distance-vector routing protocol. RIP is documented in RFC 1058. RIPv2 is defined by RFC2453.

ZXR10 5900/5200 supports RIPv1 and RIPv2 and adopts RIPv2 by default. Comparing with RIPv1, RIPv2 has the following advantages:

- Subnet mask contained in the routing update
- Authentication of the routing update
- Multicast route update

RIP Routing Metric

RIP uses the UDP packet (port number 520) to exchange RIP routing information. Routing information in the RIP packet includes the number of routers that a route passes (that is, hops). Router determines the route to the destination network according to hops. RFC stipulates that the maximum hop count cannot go beyond 16, so RIP is only applicable to a small-sized network. Hop count 16 indicates the infinite distance and this means that the route is unreachable. Besides, this is a method for RIP to identify and avoid route loop.

RIP only takes the hop count as the metric and does not consider the bandwidth, delay or other variable factors during the routing. RIP always takes the path with the minimum hop count as the

optimal path which sometimes results in that the selected path is not the best one.

Administrative Distance (AD) of RIP is 120 by default. Smaller the AD value, more reliable the routing source is. Therefore, comparing with other routing protocols, RIP is not so reliable.

RIP Timer

The router running RIP sends a routing information update packet reflecting all the routing information of the router at intervals (30 seconds by default), which is called the routing information announcement. If a router cannot receive update information from another router within a period of time (180 seconds by default), it will label the route provided by this router as unavailable. If update information still cannot be received within the subsequent period of time (240 seconds), the router eliminates the route from the routing table. Holddown timer introduces a certain amount of skepticism to reduce the acceptance of bad routing information. If the distance to a destination increases, for example, the hop count increases from two to four, the router sets a holddown timer for that route. Until the timer expires, the router will not accept any new updates for the route.

RIP provides four timers:

- Update timer
- Invalid timer
- Holddown timer
- Flush timer

Route Updates

RIP sends routing-update messages at regular intervals and when network topology changes. When a router receives a routing update that includes changes to an entry, it updates its routing table to reflect the new route. The metric value for path is increased by 1, and the sender is indicated as the next hop. RIP routers only maintain best route (the route with the lowest metric value) to a destination.

After updating its routing table, router immediately transmits routing updates to inform other network routers of the change. These updates are sent independently of the regularly scheduled updates that RIP routers send.

Configuring RIP

Enabling RIP

Step	Command	Function
1	ZXR10#ZXR10(config)#**router rip**	This enables RIP.
2	ZXR10(config-router)#**network** *<ip-address><net-mask>*	This associates a network with RIP routing process.

Adjusting RIP Timer

Command	Function
ZXR10(config-router)#**timers basic** *<update><invalid><holddown><flush>*	This adjusts timer for better RIP performance.

Configuring RIP Neighbor

Command	Function
ZXR10(config-router)#**neighbor** *<ip-address>*	This configures neighbor router which exchanges routing information with this router.

Configuring RIP Authentication

To specify the type of authentication used in RIP Version 2 packets, designate the key for interface simple text authentication, use the following command.

Step	Command	Function
1	ZXR10(config-if-vlanX)#**ip rip authentication key** *<key>*	This designates the key for interface simple text authentication.
2	ZXR10(config-if-vlanX)#**ip rip authentication mode** {**text**|**md5**}	This designates the authentication type for RIP packet.

Configuring split horizon mechanism

Command	Function
`ZXR10(config-if-vlanX)#` **ip split-horizon**	This enables the split horizon mechanism.

Configuring Poison Reverse Mechanism

Command	Function
`ZXR10(config-if-vlanX)#`**ip poison-reverse**	This enables the poison reverse mechanism.

Redistributing a Route

Command	Function
`ZXR10(config-router)#`**redistribute** <*protocol*>[**metric** <*metric-value*>][**route-map** <*map-tag*>]	This redistributes a route from another routing domain to trip routing domain.

Configuring RIP Version

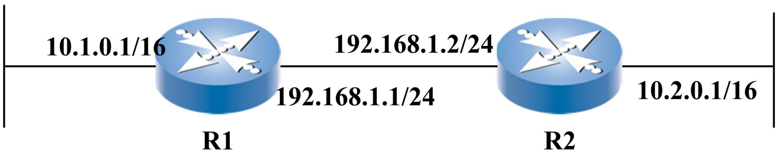
ZXR10 5900/5200 supports RIPv1 and RIPv2. RIPv2 is adopts by default.

Step	Command	Function
1	`ZXR10(config-router)#`**version**{**1**|**2**}	This designates the global RIP version of the router.
2	`ZXR10(config-if-vlanX)#`**ip rip receive version** {**1**|**2**}[**1**|**2**]	This designates the RIP version received by the interface.
3	`ZXR10(config-if-vlanX)#`**ip rip send version** {**1**|**2** {**broadcast**|**multicast**}}	This designates the RIP version sent by the interface.

RIP Configuration Example

As shown in Figure 4, RIP runs on router R1 and router R2.

FIGURE 4 BASIC RIP CONFIGURATION



R1 Configuration:

```
ZXR10_R1(config)#router rip
ZXR10_R1(config-router)#network 10.1.0.0 0.0.255.255
ZXR10_R1(config-router)#network 192.168.1.0 0.0.0.255
ZXR10_R1(config-router)#no auto-summary
```

R2 configuration:

```
ZXR10_R2(config)#router rip
ZXR10_R2(config-router)#network 10.2.0.0 0.0.255.255
ZXR10_R2(config-router)#network 192.168.1.0 0.0.0.255
ZXR10_R1(config-router)#no auto-summary
```

The result is viewed as follows:

```
ZXR10_R2(config)#show ip rip database
Routes of rip:
h : is possibly down,in holddown time
f : out holddown time before flush

       Dest              Metric     RtPrf        Time          From
*>  10.2.0.0/16            0          0        00:00:00       0.0.0.0
*>  10.1.0.0/16            2          120      00:00:09       192.168.1.1
*>  192.168.1.0/24         0          0        00:00:00       0.0.0.0
```

RIP Maintenance and Diagnosis

ZXR10 5900/5200 provides **show** command for RIP maintenance and diagnosis.

Step	Command	Function
1	ZXR10#**show ip rip**	This displays protocol information.
2	ZXR10#**show ip rip interface** *<interface-name>*	This shows rip routing interface and its parameters information.
3	ZXR10#**show ip rip database**	This displays the entire routing entry database.
4	ZXR10#**show ip rip networks**	This displays all the RIP interfaces configured by users.

Step	Command	Function
5	ZXR10#**show ip route** [<*ip-address*><*net-mask*>] **rip**	This displays global routing table and if RIP is in the routing table.
6	ZXR10#**show ip forwarding subnetrt** <*ip-address*><*net-mask*>	This displays driving hardware routing table and if hardware routing table is same as global routing table.

ZXR10 5900/5200 also provides **debug** command for RIP maintenance and diagnosis.

Step	Command	Function
1	ZXR10#**debug ip rip**	This traces the basic RIP sending and receiving packet.
2	ZXR10#**debug ip rip database**	This traces the change process of the RIP routing table.

This example shows a debug output example of the **debug ip rip** command.

```
ZXR10#debug ip rip
RIP protocol debugging is on
ZXR10#
11:01:28: RIP: building update entries
130.1.0.0/16 via 0.0.0.0, metric 1, tag 0
130.1.1.0/24 via 0.0.0.0, metric 1, tag 0
177.0.0.0/9 via 0.0.0.0, metric 1, tag 0
  193.1.168.0/24 via 0.0.0.0, metric 1, tag 0
   197.1.0.0/16 via 0.0.0.0, metric 1, tag 0
   199.2.0.0/16 via 0.0.0.0, metric 1, tag 0
   202.119.8.0/24 via 0.0.0.0, metric 1, tag 0
11:01:28: RIP: sending v2 periodic update to 224.0.0.9 via
 vlan10 (193.1.1.111)
   130.1.0.0/16 via 0.0.0.0, metric 1, tag 0
   130.1.1.0/24 via 0.0.0.0, metric 1, tag 0
   177.0.0.0/9 via 0.0.0.0, metric 1, tag 0
   193.1.1.0/24 via 0.0.0.0, metric 1, tag 0
11:01:28: RIP: sending v2 periodic update to 193.1.168.95
 via vlan20 (193.1.168.111)
11:01:28: RIP: sending v2 periodic update to 193.1.168.86
via vlan20 (193.1.168.111)
11:01:28: RIP: sending v2 periodic update to 193.1.168.77
via vlan20 (193.1.168.111)
11:01:28: RIP: sending v2 periodic update to 193.1.168.68
via vlan20 (193.1.168.111)
```

Chapter 3

OSPF Configuration

Table of Contents

OSPF Overview 13
Configuring OSPF 19
OSPF Configuration Example 23
OSPF Maintenance and Diagnosis 30

OSPF Overview

OSPF Basics

Open Shortest Path First (OSPF) is one of the most popular and widely used routing protocols. OSPF is a replacement for the problematic Routing Information Protocol (RIP) and other distance vector protocols. OSPF major advantage is that it supports for much larger inter-networks and less susceptibility to bad routing information.

OSPF Version 1 is defined by RFC1131. OSPF Version 2 is defined by RFC2328 and presently in use. ZXR10 5900/5200 fully supports OSPF Version 2.

OSPF has the following features:

- OSPF contains the flow of routing protocol traffic and makes possible construction of hierarchical inter-network topologies.
- There is no routing loop. The shortest path first (SPF) algorithm ensures a loop free network.
- Route aggregation decreases the routing table size.
- Support of classless route table lookups, Variable Length Subnet Mask (VLSM) and Classless Inter-Domain Routing (CIDR).
- Less network bandwidth is needed because the adopted update trigger mechanism sends update information only when the network topology changes.
- Support of authentication for more secure routing.
- Update information can be multicasted instead of being broadcasted, which reduces the impact on irrelevant network devices.

OSPF Algorithm

As OSPF is a link state protocol. OSPF router generates a routing table by setting up a link state database, which contains the information of all networks and routers. Routers use this information to establish routing tables. To ensure reliability, all routers must have the same link state database.

Link state database is built, based on Link State Advertisements (LSAs) ,which are generated by all routers and spread over the whole OSPF network. There are many types of LSAs, a complete LSA set shows an accurate distribution diagram over the whole network.

OSPF uses cost as the metric. The cost is distributed to each port of a router. A port calculates the cost, that is based on a 100M benchmark by default. The path cost to a particular destination is the total cost of all links between the router and the destination.

To generate a routing table, based on the LSA database, a router runs the Dijkstra SPF algorithm to construct a cost routing tree with itself as the root of the routing tree. The Dijkstra algorithm enables a router to calculate the lowest-cost path between itself and any node on the network. Router saves the routes of the paths in the routing table.

Different from RIP, OSPF does not simply broadcast all of its routing information regularly. An OSPF router sends call messages to its neighbors to let them know it is still alive. If a router does not receive any message from a neighbor within a period of time then the neighbor might not be alive.

OSPF routing is incrementally updated. Router sends the update information only when topology changes. When the age of an LSA reaches 1800 seconds, a new version of the LSA is resent.

OSPF Network Types

Type of the network connecting to a port is used to determine the default OSPF behavior on that port. The network type affects the adjacency relationship and how the router designates a timer to the port.

There are five network types in OSPF, and they are as follows:

- Broadcast
- Non-broadcast Multi-access (NBMA) networks
- Point-to-Point networks
- Point-to-multipoint networks
- Virtual links

Hello Packet and Timer

Hello protocol serves several purposes:

- It is the means by which neighbors are discovered.
- It advertises several parameters on which two routers must agree before they can become neighbors.
- Hello packets act as keepalives between neighbors.
- It ensures bi-directional communication between neighbors.
- It elects designated routers and backup designated routers on Broadcast and Nonbroadcast Multiaccess (NBMA) networks.

OSPF uses three types of timers related to the Hello Packet.

HelloInterval is an attribute of an interface. It defines the length of time between Hello Packets that the router sends on the interface. Default HelloInterval depends on the network type. On the broadcast and point-to-point networks the default HelloInterval is 10 seconds. On NBMA and point-to-multipoint networks it is 30 seconds. The router's neighbor routers must agree on the HelloInterval to enable them to become neighbors.

It is number of seconds before the router's neighbors will declare it down. When they stop receiving the router's Hello Packets. The default RouterDeadInterval is four times as long as the HelloInterval, which applies to all the network types.

PollInterval is only used on the NBMA network.

OSPF Neighbor

OSPF neighbors are a group of routers on the same network. They have some of the same configuration parameters. Routers must first be neighbors before they can set up adjacency relationship.

Routers analyze the Hello Packets from each other when they become neighbors to make sure the required parameters are stipulated. Parameters include area ID, area flag, authentication information, HelloInterval and RouterDeadInterval.

Adjacency and Designated Routers

Two routers when set up adjacency relationship. They can exchange routing information. Whether two routers can set up an adjacency relationship depends on the type of the network connecting the routers.

There are only two routers in point-to-point network and virtual links. Routers set up an adjacency relationship automatically. The point-to-multipoint network can be regarded as a set of point-to-point networks. Each pair of routers set up an adjacency relationship automatically.

Neighbors do not necessarily have the adjacency relationship, on broadcast and NBMA networks. If all routers (the number is n) on a network have set up the adjacency relationship, each router has (n-1) adjacency relationships and there are n (n-1)/2 adjacency relationships on the network. Tracking so many adjacency relationships on a large multi-access network will impose a heavy burden on each router. Routing information between each pair of neighbor routers will waste a great deal of network bandwidth.

OSPF defines a Designated Router (DR) and a Backup Designated Router (BDR). Designated Router (DR) has following duties:

- To represent a multi-access network and it's attached routers to the rest of the internetwork.
- To manage the flooding process on the multi-access network.

DR and BDR must establish an adjacency relationship with each OSPF router over the network. Each OSPF router only establishes adjacency relationships with DR and BDR. If the DR stops working then BDR take its place and becomes DR.

Router Priority and DR Election

Each multi-access interface of each router has a Router Priority, which is an 8-bit unsigned integer ranging from 0 to 255. Default priority is 1.

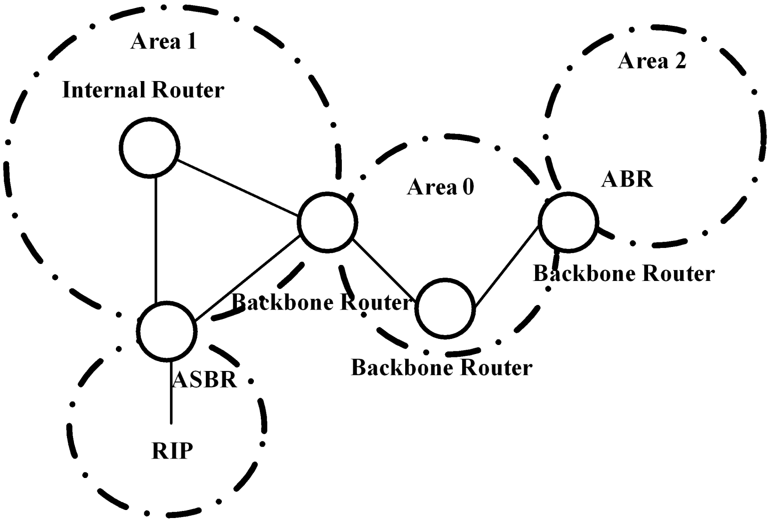
During the DR election, the router with the highest priority becomes the DR. If all routers have the same priority, the one with the highest IP address will be elected as the DR. Routers with a priority of 0 are ineligible to become the DR or BDR.

OSPF Area

A network is divided into several smaller OSPF areas to reduce the information that each router stores and maintains. Each router must have the complete information of its area. Areas can share their information. Routing information can be filtered out on the area edge to reduce the routing information stored in routers.

Each area is identified by a 32-bit unsigned number. Area 0 is used to identify the backbone area. All the other areas must directly connect to Area 0. An OSPF network must have one backbone area. Based on its tasks in the area, a router can be of one or multiple of the following roles, as shown in Figure 5 .

FIGURE 5 OSPF ROUTER TYPES



- Internal router: Router's interface is in the same area.
- Backbone router: Router has at least one interface in Area 0.
- Area Border Router (ABR): Router has at least one interface in Area 0 and at least one interface in another area.
- Autonomous System Border Router (ASBR): Router connects an AS that runs OSPF to another AS that runs another protocol, such as RIP and IGRP.

LSA Type and Flooding

OSPF routers useLSAs to exchange information for the link state database. LSAs set up an accurate and complete network diagram routes in a routing table. ZXR10 5900/5200 supports six types of LSAs:

- Type 1Router LSA
- Type 2Network LSA
- Type 3Network Summary LSA
- Type 4ASBR Summary LSA
- Type 5AS External LSA
- Type 7NSSA External LSA

OSPF operations are determined by all routers that share one public link state database in a region. Therefore all LSAs need to be flooded over the region and the processing must be reliable. Each router sends the LSAs that it receives from a particular area to the other interfaces in the area. Instead of being packets, LSAs are contained in Link State Update (LSU) packets. Several LSAs can be included in one LSU. When a router receives an LSU packet instead of forwarding it directly, router extracts LSAs from the packet and puts them into its database. In addition, the router constructs its

own LSU and forwards the modified LSU to neighbors connecting to it.

OSPF sends Link State Acknowledgements (LSAck) to make sure that each LSA is received by neighbors. An LSAck contains the head of the confirmed LSA, which is sufficient for identifying an LSA uniquely. When a router sends an LSA to an interface, the LSA is recorded in the resend queue of the interface. Router will wait the preset time for the LSAck of the LSA. If it does not receive the LSAck within the preset time, it will resend the LSA. A router can send the original LSU by both unicast and multicast but can resend the LSU only by unicast.

Stub Area and Totally Stub Area

A stub area is an area into which AS External LSAs are not flooded. If type 5 LSAs are not known inside an area, type 4 LSAs are unnecessary; these LSAs are blocked. ABRs at the edge of a stub area will use Network Summary LSAs to advertise a single default route into the area.

In a stub area, all routers must be configured as stub routers. Hello Packet contains a "stub area" flag bit, which must be consistent among neighbors.

ABR in a stub area can filter out type 5 LSAs to prevent them from being advertised to the stub area. In addition, the ABR will generate a type 3 LSA to advertise a default route to destination addresses outside the AS.

ABR also filters out the Type 3 LSAs and advertises a default route to destination addresses outside of the area, this area is called totally stubby area.

Not-So-Stubby Area

Routers in a stub area do not allow type 5 LSAs so the ASBR is not part of a stub area. To create a stub area with ASBR, routers in this area receive from the ASBR the routes outside of the AS but external routing information from other areas is blocked.

Not-so-stubby area (NSSA) allows external routes to be advertised into the OSPF autonomous system while retaining the characteristics of a sub area to the rest of the autonomous system. To do this, the ASBR in an NSSA originates type 7 LSAs to advertise the external destinations. These NSSA External LSAs are flooded throughout the NSSA but are blocked at the ABR. On the other hand, it converts type 7 LSAs into type 5 LSAs.

OSPF Authentication

Authentication applies to packet exchange between OSPF neighbors. Neighbors must agree on the authentication type, which is included in all packets.

When simple password authentication is configured, one interface can have only one password and each interface can have a different passwords all interfaces in a particular network must have the same password. Simple password is transmitted in plain text by OSPF packets.

Configuring OSPF

Enabling OSPF

Command	Function
`ZXR10(config)#`**router ospf** <*process-id*>	This enables OSPF routing.

Configuring Interface Timer

Step	Command	Function
1	`ZXR10(config-if-vlanX)#`**ip ospf hello-interval**<*seconds*>	This designates an interval at which an interface sends Hello packets.
2	`ZXR10(config-if-vlanX)#`**ip ospf retransmit-interval** <*seconds*>	This designates the interval at which an interface retransmits an LSA.
3	`ZXR10(config-if-vlanX)#`**ip ospf transmit-delay**<*seconds*>	This designates the delay after which an interface transmits a LSU packet.
4	`ZXR10(config-if-vlanX)#`**ip ospf dead-interval**<*seconds*>	This designates the dead interval for a neighbor on an interface.

Configuring Interface Cost

Command	Function
ZXR10(config-if-vlanX)#**ip ospf cost**<*cost*>	This configures interface cost.

Configuring Interface Priority

Command	Function
ZXR10(config-if-vlanX)#**ip ospf priority**<*priority*>	This configures interface priority.

Configuring Neighbor Routers

Command	Function
ZXR10(config-router)#**neighbor** <*ip-address*>[**cost** <*cost*>][**priority** <*priority*>][**poll-interval** <*seconds*>]	This designates the neighbor routers on a non-broadcast.

Configuring OSPF Area

OSPF uses area to implement the hierarchical routing. OSPF areas are divided into stub area, totally stubby area and not-so-stubby area. Backbone area is a transitional area.

Step	Command	Function
1	ZXR10(config-router)#**area** <*area-id*> **stub** [**no-summary**][**default-cost** <*cost*>]	This defines an area as a stub area or totally stubby area.
2	ZXR10(config-router)#**area** < *area-id*> **nssa** [**no-redistribution**][**default-information-originate** [**metric** < *metric-value*>][**metric-type** < *type*>][**no-redistribution**][**no-summary**]][**no-summary**]	This defines an area as a not-so-stubby area.

Configuring Inter-Area Route Aggregation

Route aggregation can occur between areas or autonomous systems (AS). Inter-area route aggregation takes place on the ABR whereas inter-AS route aggregation happens on the ASBR.

Configuring a stub area can save resources on routers in the stub area but it does not help the backbone area.

If network addresses in an area are allocated in sequence, configure ABR to advertise an aggregate route to replace the sequential routes. Route aggregation can save resources in the backbone area by advertising a summary address for a group of network addresses.

Command	Function
`ZXR10(config-router)#`**area** *<area-id>* **range** *<ip-address><net-mask>*[**advertise**|**not-advertise**]	This configures the range of summary addresses in the area.

Notifying Default Route

When a router uses redistributed routes it becomes an ASBR. ASBR does not automatically advertise the default route to the whole OSPF area by default.

Command	Function
`ZXR10(config-router)#`**notify default route** [**always**][**metric** *<metric-value>*][**metric-type** *<type>*][**route-map** *<map-tag>*]	This notifies default route.

Configuring Virtual Link

All areas on an OSPF network must directly connect to the backbone area, which will set a limit to the layout of areas especially when the network is very large. To overcome this problem, a virtual link can be used to connect a remote area to the backbone area through another area. The area that the virtual link crosses must have complete routing information, so it cannot be a stub area.

Command	Function
`ZXR10(config-router)#`**area** < *area-id*> **virtual-link** < *router-id*>[**hello-interval** < *seconds*>][**retransmit-intervall** < *seconds*>][**transmit-delay** < *seconds*>][**dead-intervall** < *seconds*>][**authentication-key** < *key*>][**message-digest-key** < *keyid*> **md5** < *cryptkey*>[**delay** < *time*>][**encrypt**]][**authentication** [**null**| **message-digest**]]	This defines an OSPF virtual link.

Redistributing Other Routing Protocols

Different dynamic routing protocols can share routing information through route redistribution. In OSPF the routing information of other routing protocols is the external routing information of an AS. Only when the AS's external routing information is redistributed to OSPF then it can spread it to the whole OSPF network.

Command	**Function**
`ZXR10(config-router)#`**redistribute** *<protocol>*[**as** *<as-number>*][**peer** *<peer-address>*][**tag** *<tag-value>*][**metric** *<metric-value>*][**metric-type** *<type>*][**route-map** *<map-tag>*]	This control the redistribution of routes of other routing protocols to the OSPF.

Configuring OSPF Authentication

In order to improve the security of routing processes, OSPF authentication can be configured on router.

Step	**Command**	**Function**
1	`ZXR10(config-router)#`**area** *<area-id>* **authentication** [**message-digest**]	This performs authentication on the OSPF area.
2	`ZXR10(config-if-vlanX)#`**ip ospf authentication-key** *<password>*	This sets a password for the interface of simple password authentication.

Enabling Routes to Support Opaque LSA

During the exchange of link state database, opaque LSAs are included in the database summary list and transmitted to the neighbor routers that also support opaque LSAs.

A router before it floods opaque LSAs to neighbor routers. It first checks whether the neighbor routers support opaque LSAs or not. Opaque LSAs are transmitted only to the neighbor routers that support the function and they will be added to the link state retransmit list of neighbor routers. When LSU packets are multicasted the neighbor routers that do not support the function receive the LSAs passively and simply discard them.

Command	**Function**
`ZXR10(config-router)#`**capability opaque**	This enables routes to support opaque LSAs.

Modifying OSPF Management Distance

Management distance is related to the reliability of the routing information source. Management distance is an integer between 0 and 255. Higher value represents lower reliability. If the management distance is 255, the routing information source is unreliable and the related routes will be ignored.

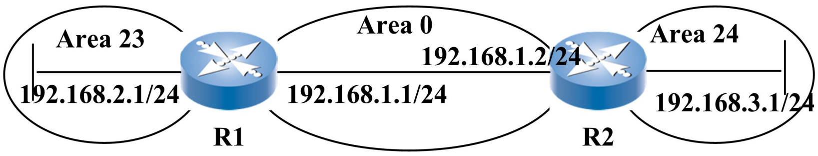
Command	Function
ZXR10(config-router)#**distance ospf** {[**internal** <*distance*>][**ext1** <*distance*>][**ext2** <*distance*>]}	This defines the OSPF route management distance based on the route type.

OSPF Configuration Example

Basic OSPF Configuration Example

Run OSPF on R1 and R2. Divide the network into three areas. This is shown in Figure 6.

FIGURE 6 BASIC OSPF CONFIGURATION



R1 configuration:

```
ZXR10_R1(config)#router ospf 1
ZXR10_R1(config-router)#network 192.168.2.0 0.0.0.255 area 23
ZXR10_R1(config-router)#network 192.168.1.0 0.0.0.255 area 0
```

R2 configuration:

```
ZXR10_R2(config)#router ospf 1
ZXR10_R2(config-router)#network 192.168.3.0 0.0.0.255 area 24
ZXR10_R2(config-router)#network 192.168.1.0 0.0.0.255 area 0
```

The result is viewed as follows:

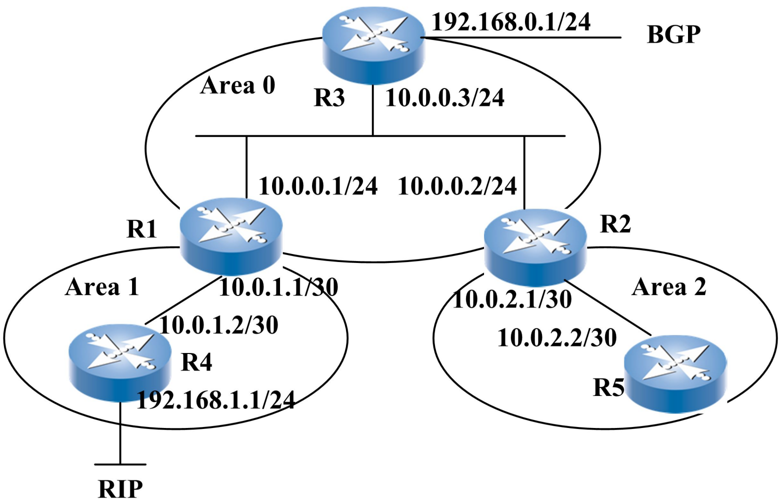
```
ZXR10_R1(config)#show ip ospf neighbor

            OSPF Router with ID (10.1.2.1) (Process ID 1)

Neighbor ID      Pri State        DeadTime  Address         Interface
10.1.1.2         1   FULL/DR      00:00:36  192.168.1.2     vlan8
```

```
ZXR10_R2(config)#show ip ospf neighbor

            OSPF Router with ID (10.1.1.2) (Process ID 1)

Neighbor ID      Pri State        DeadTime  Address         Interface
10.1.2.1         1   FULL/BDR     00:00:30  192.168.1.1     vlan8
```

Multi-Area OSPF Configuration Example

When a network is big, it should be divided into multiple OSPF areas. This is shown in Figure 7 as an example of multi-area OSPF.

FIGURE 7 MULTI-AREA OSPF CONFIGURATION



1. Area 0.0.0.1 is a NSSA; R1 is an ABR working between the NSSA 0.0.0.1 and the backbone area. R1 advertises a default route in the local area.

   R1 configuration:

```
ZXR10_R1(config)#interface vlan 1
ZXR10_R1(config-if-vlan1)#ip address 10.0.1.1 255.255.255.252
ZXR10_R1(config-if-vlan1)#exit
ZXR10_R1(config)#interface vlan2
ZXR10_R1(config-if-vlan2)#ip address 10.0.0.1 255.255.255.0
ZXR10_R1(config-if-vlan2)#exit
ZXR10_R1(config)#router ospf 1
ZXR10_R1(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R1(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R1(config-router)#area 0.0.0.1 nssa  default-information-originate
```

2. Area 0.0.0.2 is a stub area; R2 is an ABR working between the Area 0.0.0.2 and the backbone area. In the stub area, the ABR advertises a default route automatically.

   R2 configuration:

```
ZXR10_R2(config)#interface vlan1
ZXR10_R2(config-if-vlan1)#ip address 10.0.2.1 255.255.255.252
ZXR10_R2(config-if-vlan1)#exit
ZXR10_R2(config)#interface vlan2
```

```
ZXR10_R2(config-if-vlan2)#ip address 10.0.0.2 255.255.255.0
ZXR10_R2(config-if-vlan2)#exit
ZXR10_R2(config)#router ospf 1
ZXR10_R2(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R2(config-router)#network 10.0.2.0 0.0.0.3 area 0.0.0.2
ZXR10_R2(config-router)#area 0.0.0.2 stub
```

3. R3 is a router in the backbone area 0 and connects to other ASs through a BGP. R3 Configuration can be done as egress router of the whole as to advertise a default route to the entire OSPF area manually.

   R3 configuration:

```
ZXR10_R3(config)#interface vlan1
ZXR10_R3(config-if-vlan1)#ip address 10.0.0.3 255.255.255.0
ZXR10_R3(config-if-vlan1)#exit
ZXR10_R3(config)#interface vlan2
ZXR10_R3(config-if-vlan2)#ip address 192.168.0.1 255.255.255.0
ZXR10_R3(config-if-vlan2)#exit
ZXR10_R3(config)#router ospf 1
ZXR10_R3(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R3(config-router)#notify default route always
```

4. R4 is the ASBR in NSSA 0.0.0.1. Both OSPF and RIP run on R4. Routes of RIP can be redistributed to OSPF.

   R4 configuration:

```
ZXR10_R4(config)#interface vlan1
ZXR10_R4(config-if-vlan1)#ip address 192.168.1.1 255.255.255.0
ZXR10_R4(config-if-vlan1)#exit
ZXR10_R4(config)#interface vlan2
ZXR10_R4(config-if-vlan2)#ip address 10.0.1.2 255.255.255.252
ZXR10_R4(config-if-vlan2)#exit
ZXR10_R4(config)#router ospf 1
ZXR10_R4(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R4(config-router)#area 0.0.0.1 nssa
ZXR10_R4(config-router)#redistribute rip metric 10
```

5. R5 is a router in stub area 0.0.0.2.

   R5 configuration:

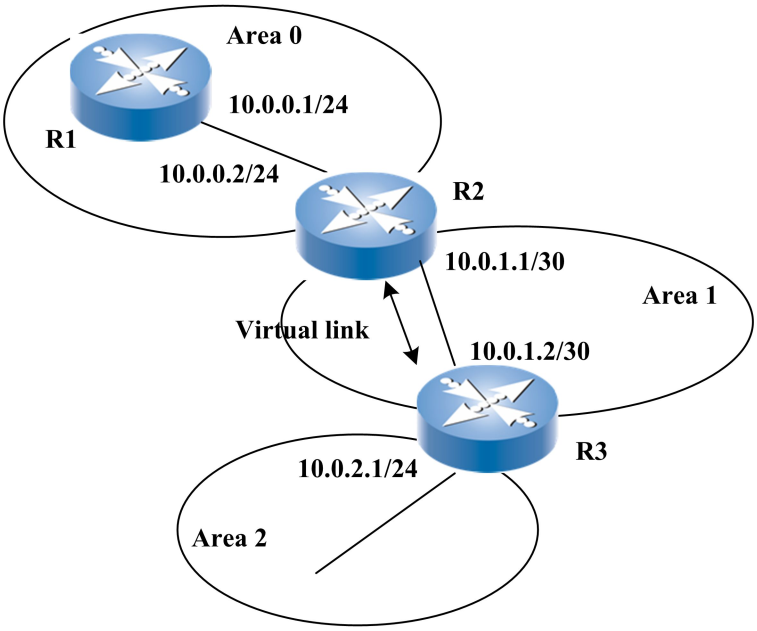
```
ZXR10_R5(config)#interface vlan1
ZXR10_R5(config-if-vlan1)#ip address 10.0.2.2 255.255.255.252
ZXR10_R5(config-if-vlan1)#exit
ZXR10_R5(config)#router ospf 1
ZXR10_R5(config-router)#network 10.0.2.0 0.0.0.3 area 0.0.0.2
ZXR10_R5(config-router)#area 0.0.0.2 stub
```

Use the **show ip ospf neighbor** command to ensure if neighbor is established.

OSPF Virtual Links Configuration Example

An OSPF virtual link is shown in Figure 8

FIGURE 8 OSPF VIRTUAL LINK



R1 configuration:

```
ZXR10_R1(config)#interface vlan1
ZXR10_R1(config-if-vlan1)#ip address 10.0.0.1 255.255.255.0
ZXR10_R1(config-if-vlan1)#exit
ZXR10_R1(config)#router ospf 1
ZXR10_R1(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
```

R2 configuration:

```
ZXR10_R2(config)#interface vlan1
ZXR10_R2(config-if-vlan1)#ip address 10.0.0.2 255.255.255.0
ZXR10_R2(config-if-vlan1)#exit
ZXR10_R2(config)#interface vlan2
ZXR10_R2(config-if-vlan2)#ip address 10.0.1.1 255.255.255.252
ZXR10_R2(config-if-vlan2)#exit
ZXR10_R2(config)#router ospf 1
ZXR10_R2(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R2(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R2(config-router)#area 1 virtual-link 10.0.1.2
```

R3 configuration:

```
ZXR10_R3(config)#interface vlan1
ZXR10_R3(config-if-vlan1)#ip address 10.0.1.2 255.255.255.252
ZXR10_R3(config-if-vlan1)#exit
ZXR10_R3(config)#interface vlan2
ZXR10_R3(config-if-vlan2)#ip address 10.0.2.1 255.255.255.0
ZXR10_R3(config-if-vlan2)#exit
ZXR10_R3(config)#router ospf 1
ZXR10_R3(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R3(config-router)#network 10.0.2.0 0.0.0.255 area 0.0.0.2
ZXR10_R3(config-router)#area 1 virtual-link 10.0.0.2
```

The result is viewed as follows:

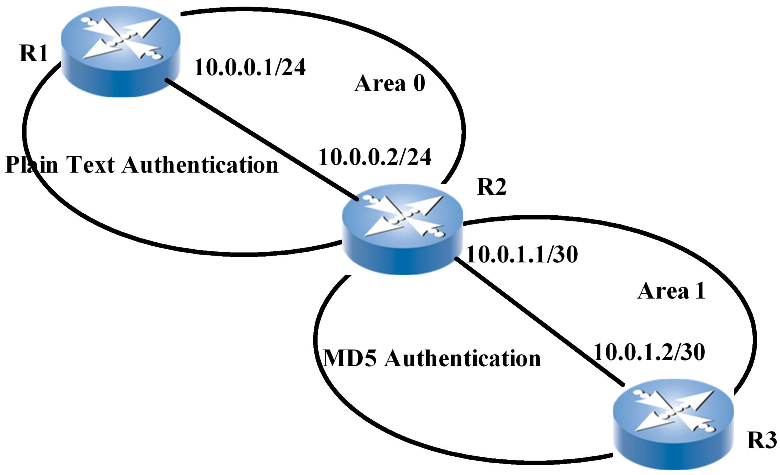
```
ZXR10_R2(config)#show ip ospf virtual-links
Virtual Link to router 10.0.1.2 is UP
  Up for 00:01:57 (Demand circuit, Suppress hello)
  Transit area 0.0.0.1
  via interface vlan8 10.0.1.1
  State PTOP, Transmit Delay(sec) 1,
  Cost 1, Authentication Type null
```

```
  Timer intervals(sec) : Hello 10, Dead 40, Retransmit 5
  Adjacency State FULL
  Dead time : no use Options : 0x62
  In Full State for 00:01:47


ZXR10_R3(config)#show ip ospf virtual-links
Virtual Link to router 10.0.0.2 is UP
  Up for 00:00:08 (Demand circuit)
  Transit area 0.0.0.1
  via interface vlan8 10.0.1.2
  State PTOP, Transmit Delay(sec) 1,
  Cost 1, Authentication Type null
  Timer intervals(sec) : Hello 10, Dead 40, Retransmit 5
  Adjacency State INIT
  Dead time : 00:00:37 Options : 0x22
  In Full State for 00:00:00
```

OSPF Authentication Configuration Example

Plain text authentication is adopted in Area 0, MD5 encrypted authentication is used in Area 1. This is shown in Figure 9.

FIGURE 9 OSPF AUTHENTICATION



R1 configuration:

```
ZXR10_R1(config)#interface vlan1
ZXR10_R1(config-if-vlan1)#ip address 10.0.0.1 255.255.255.0
ZXR10_R1(config-if-vlan1)#ip ospf authentication-key ZXR10
ZXR10_R1(config-if-vlan1)#exit
ZXR10_R1(config)#router ospf 1
ZXR10_R1(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R1(config-router)#area 0 authentication
```

R2 configuration:

```
ZXR10_R2(config)#interface vlan1
ZXR10_R2(config-if-vlan1)#ip address 10.0.0.2 255.255.255.0
ZXR10_R2(config-if-vlan1)#ip ospf authentication-key ZXR10
ZXR10_R2(config-if-vlan1)#exit
ZXR10_R2(config)#interface vlan2
ZXR10_R2(config-if-vlan2)#ip address 10.0.1.1 255.255.255.252
```

```
ZXR10_R2(config-if-vlan2)#ip ospf message-digest-key 1 md5 ZXR10
ZXR10_R2(config-if-vlan2)#exit
ZXR10_R2(config)#router ospf 1
ZXR10_R2(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
ZXR10_R2(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R2(config-router)#area 0 authentication
ZXR10_R2(config-router)#area 1 authentication message-digest
```

R3 configuration:

```
ZXR10_R3(config)#interface vlan1
ZXR10_R3(config-if-vlan1)#ip address 10.0.1.2 255.255.255.252
ZXR10_R3(config-if-vlan1)#ip ospf message-digest-key 1 md5 ZXR10
ZXR10_R3(config-if-vlan1)#exit
ZXR10_R3(config)#router ospf 1
ZXR10_R3(config-router)#network 10.0.1.0 0.0.0.3 area 0.0.0.1
ZXR10_R3(config-router)#area 1 authentication message-digest
```

The result is viewed as follows:

```
ZXR10_R1(config)#show ip ospf 1
OSPF 1 enable
 Router ID 10.1.1.1
 Domain ID type 0x5,value 0.0.0.1
 Enabled for 02:32:48,Debug on
 Number of areas 3, Normal 3, Stub 0, NSSA 0
 Number of interfaces 1
 Number of neighbors 1
 Number of adjacent neighbors 1
 Number of virtual links 0
 Total number of entries in LSDB 11
 Number of ASEs in LSDB 0, Checksum Sum 0x00000000
 Number of grace LSAs 0
 Number of new LSAs received 16
 Number of self originated LSAs 112
 Hold time between consecutive SPF 1 secs
 Non-stop Forwarding disabled, last NSF restart 02:39:27 ago (took 0 secs)

     Area 0.0.0.0 enable (Demand circuit available)
        Enabled for 02:31:56
        Area has simple password authentication
        Times spf has been run 22
        Number of interfaces 1. Up 1
        Number of ASBR local to this area 0
        Number of ABR local to this area 2
        Total number of intra/inter entries in LSDB 4. Checksum Sum 0x00028590
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0

     Area 0.0.0.1 enable (Demand circuit available)
        Enabled for 01:29:29
        Area has no authentication
        Times spf has been run 27
        Number of interfaces 0. Up 0
        Number of ASBR local to this area 0
        Number of ABR local to this area 1
        Total number of intra/inter entries in LSDB 4. Checksum Sum 0x0002a5bc
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0

     Area 0.0.0.23 enable (Demand circuit available)
        Enabled for 02:32:28
        Area has no authentication
        Times spf has been run 45
        Number of interfaces 0. Up 0
        Number of ASBR local to this area 0
        Number of ABR local to this area 1
        Total number of intra/inter entries in LSDB 3. Checksum Sum 0x0001cf91
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0
```

```
ZXR10_R2(config)#show ip ospf 1
OSPF 1 enable
 Router ID 10.0.1.2
 Domain ID type 0x5,value 0.0.0.1
 Enabled for 01:46:47,Debug on
 Number of areas 3, Normal 3, Stub 0, NSSA 0
 Number of interfaces 2
 Number of neighbors 1
 Number of adjacent neighbors 1
 Number of virtual links 0
 Total number of entries in LSDB 12
 Number of ASEs in LSDB 0, Checksum Sum 0x00000000
 Number of grace LSAs 0
 Number of new LSAs received 16
 Number of self originated LSAs 31
 Hold time between consecutive SPF 1 secs
 Non-stop Forwarding disabled, last NSF restart 01:49:58 ago (took 0 secs)

     Area 0.0.0.0 enable (Demand circuit available)
        Enabled for 01:44:59
        Area has simple password authentication
        Times spf has been run 5
        Number of interfaces 1. Up 1
        Number of ASBR local to this area 0
        Number of ABR local to this area 2
        Total number of intra/inter entries in LSDB 4. Checksum Sum 0x00028391
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0

     Area 0.0.0.1 enable (Demand circuit available)
        Enabled for 01:46:26
        Area has MD5 authentication
        Times spf has been run 15
        Number of interfaces 1. Up 1
        Number of ASBR local to this area 0
        Number of ABR local to this area 1
        Total number of intra/inter entries in LSDB 5. Checksum Sum 0x0002c08e
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0

     Area 0.0.0.2 enable (Demand circuit available)
        Enabled for 01:46:07
        Area has no authentication
        Times spf has been run 3
        Number of interfaces 0. Up 0
        Number of ASBR local to this area 0
        Number of ABR local to this area 1
        Total number of intra/inter entries in LSDB 3. Checksum Sum 0x0001e787
        Area-filter out not set
        Area-filter in not set
        Area ranges count 0
```

```
ZXR10_R3(config)#show ip ospf 1
OSPF 1 enable
 Router ID 10.0.1.2
 Domain ID type 0x5,value 0.0.0.1
 Enabled for 00:00:58,Debug on
 Number of areas 1, Normal 1, Stub 0, NSSA 0
 Number of interfaces 1
 Number of neighbors 0
 Number of adjacent neighbors 0
 Number of virtual links 0
 Total number of entries in LSDB 1
 Number of ASEs in LSDB 0, Checksum Sum 0x00000000
 Number of grace LSAs 0
 Number of new LSAs received 0
 Number of self originated LSAs 1
 Hold time between consecutive SPF 1 secs
```

```
Non-stop Forwarding disabled, last NSF restart 00:14:15 ago (took 0 secs)

    Area 0.0.0.1 enable (Demand circuit available)
       Enabled for 00:00:12
       Area has MD5 authentication
       Times spf has been run 1
       Number of interfaces 1. Up 0
       Number of ASBR local to this area 0
       Number of ABR local to this area 0
       Total number of intra/inter entries in LSDB 1. Checksum Sum 0x00008e9a
       Area-filter out not set
       Area-filter in not set
       Area ranges count 0
```

OSPF Maintenance and Diagnosis

ZXR10 5900/5200 provides show command for maintenance and diagnosis.

Step	Command	Function
1	ZXR10#**show ip ospf**	This views OSPF process detail.
2	ZXR10#**show ip ospf interface** [<*interface-name*>][**process** <*process-id*>]	This checks the current configuration and state of an OSPF interface.
3	ZXR10#**show ip ospf neighbor** [**interface** <*interface-name*>][**neighbor-id** <*neighbor*>][**process** <*process-id*>]	This checks the information of OSPF neighbors.
4	ZXR10#**show ip ospf database**	This displays all or part of the information of the link state database.
5	ZXR10#**show ip route ospf**	This displays router global routing table and views if OSPF route is in routing table.
6	ZXR10#**show ip forwarding subnetrt** <*ip-address*><*net-mask*>	This views driving hardware routing table and view if hardware routing table is same as global routing table.

ZXR10 5900/5200 also provides debug command for maintenance and diagnosis.

Step	Command	Function
1	ZXR10#**debug ip ospf adj**	This enables OSPF adjacency relationship debugging.

Step	Command	Function
2	ZXR10#**debug ip ospf packet**	This enables OSPF packet transmission, receipt debugging, listen to receipt and transmission of all OSPF packets.
3	ZXR10#**debug ip ospf lsa-generation**	This enables OSPF LSA generation debugging.
4	ZXR10#**debug ip ospf events**	This enables OSPF important events debugging.

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Chapter 4

IS-IS Configuration

Table of Contents

IS-IS Overview 33
Configuring IS-IS 36
IS-IS Configuration Example 38
IS-IS Maintenance and Diagnosis.......................................42

IS-IS Overview

IS-IS Overview

Intermediate System-to-Intermediate System (IS-IS) is a routing protocol that is introduced by the International Organization for Standardization (ISO) for Connectionless Network Service (CLNS). IS-IS works on the network layer of the Open Systems Interconnection (OSI). When IS-IS is expanded and added with the function to support IP routing, it becomes Integrated IS-IS. IS-IS introduced in this document refers to Integrated IS-IS.

IS-IS is widely used as an Interior Gateway Protocol (IGP) on networks. On the surface, OSPF and IS-IS have many features in common:

- They both maintain a link state database from which a Dijkstra-based SPF algorithm computers a shortest-path tree.
- They both use Hello packets to form and maintain adjacencies.
- They both use areas to form a two-level hierarchical topology.
- They both have the capability of providing address summarization between areas.
- They both are classless protocols.
- They both have authentication capabilities.

Since the IS-IS protocol is based on CLNS (not IP), IS-IS uses Protocol Data Unit (PDU) defined by ISO to implement communications among routers. The types of PDUs used in IS-IS protocol are as follows:

- Call PDU
- Link state PDU (LSP)
- Sequence Number PDU (SNP)

Where, call PDU is similar to the HELLO packet in the OSPF protocol, which is responsible for the formation of the adjacency between routers, discovery of new neighbors and the detection of exit of any neighbors.

IS-IS routers exchange routing information, set up and maintain link state database by use of link state PDUs. An LSP indicates important information about a router, covering area and connected network. SNP is used to ensure reliable transmission of LSPs. SNP contains summary information about each LSP on a network.

When a router receives an SNP, it compares SNP with link state database. If router loses an LSP in SNP, it originates a multicast SNP and asks for necessary LSPs from other routers on the network. LSPs are used in conjunction with SNPs so that IS-IS protocol can complete reliable route interaction on a large network.

Likewise, the IS-IS protocol also uses Dijkstra SPF algorithm to calculate routes. Based on the link state database, the IS-IS protocol uses SPF algorithm to calculate the best route and then adds the route to the IP routing table.

IS-IS Area

For convenience of link-state database management, concept of IS-IS area is introduced. Routers in an area are only responsible for maintaining the link state database in the local area to reduce the traffic of the routers themselves.

IS-IS areas are classified into backbone areas and non-backbone areas:

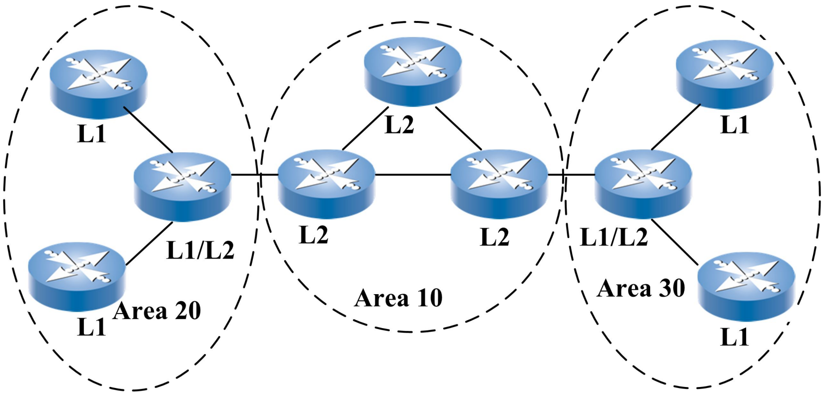
- Routers in the backbone area have the information about the database of the entire network.
- Routers in a non-backbone area only have information about the area.

Based on the area division, IS-IS defines three types of routers:

- Level 1 router exists in a non-backbone area and only exchanges routing information with L1 router and L1/L2 router in the area.
- Level 2 router exists in the backbone area and exchanges routing information with other L2 routers and L1/L2 routers.
- Level 1/Level 2 routers exist in a non-backbone area and exchanges routing information between non-backbone area and the backbone area.

This IS-Is area division and router types are shown in Figure 10.

FIGURE 10 IS-IS AREAS



IS-IS Network Type

There are two network types in IS-IS: broadcast network and point-to-point network which make IS-IS easy for configuration and implementation.

DIS and Router Priority

In a broadcast network IS-IS protocol is similar to OSPF protocol and uses designated router (DIS that is Designated Intermediate System). The DIS is responsible for advertising network information to all routers on the broadcast network and meanwhile all other routers only advertise one adjacency to the DIS.

The router priority parameters can be IS-IS configured for DIS election. L1 and L2 can be independently IS-IS configured with different priorities. Upon DIS election, a highest priority router plays the role of DIS.

If priorities are same for a frame relay interface, a router with higher router ID will be elected as the DIS. While for an Ethernet interface, a router with higher interface MAC value will be elected as the DIS.

Configuring IS-IS

Enabling IS-IS

Command	Function
ZXR10(config)# **router isis**	This enables the IS-IS routing process.

Configuring IS-IS Global Parameters

IS-IS parameter configuration covers global parameters and interface parameters. IS-IS global parameters need to be configured in the IS-IS route mode.

1. To define the operation type, use the following command.

Command	Function
ZXR10(config-router)#**is-type** {**level-1**|**level-1-2**|**level-2-only**}	This defines the operation type.

2. To define PSNP (Sequence Number PDU) for point to point networks, use the following command.

Command	Function
ZXR10(config-if-vlanX)#**isis psnp-interval** <*interval*>[**level-1**|**level-2**]	This defines PSNP (Sequence Number PDU) for point to point networks.

3. To notify insufficient resources of router running as IS-IS protocol, use the following command.

Command	Function
ZXR10(config-router)#**set-overload-bit**	This notifies insufficient resources of router running as IS-IS protocol.

4. To configure the policy for advertising the default route, use the following command.

Command	Function
ZXR10(config-router)#**default-information originate** [**always**][**metric** <*metric-value*>][**metric-type** <*type*>][**level-1**|**level-1-2**|**level-2**]	This configures the policy for advertising the default route.

5. To summarize entries in IS-IS routing table, use the following command.

Command	Function
ZXR10(config-router)#**summary-address** < *ip-address*>< *net-mask*>[**metric**]< *metric-value*>[[**level-1**| **level-1-2**| **level-2**][**metric**]< *metric-value*>]	This summarizes entries in IS-IS routing table.

Configuring IS-IS Interface Parameters

Interface IS-IS parameters need to be configures on the interface running IS-IS.

Step	Command	Function
1	ZXR10(config-if-vlanX)#**isis circuit-type** {**level-1**|**level-1-2**|**level-2-only**}	This designates an operation types for an interface.
2	ZXR10(config-if-vlanX)#**isis hello-interval** <*interval*>[**level-1**|**level-2**]	This defines an interval for adjacent routers hello packet.
3	ZXR10(config-if-vlanX)#**isis hello-multiplier** <*multiplier*>[**level-1**|**level-2**]	This configures isis hello-multiplier in order to save time for sending hello packets.
4	ZXR10(config-if-vlanX)#**isis lsp-interval** <*interval*>[**level-1**|**level-2**]	This sets time interval for transmitting LSP packets.
5	ZXR10(config-if-vlanX)#**isis retrasmit-interval** <*interval*>[**level-1**|**level-2**]	This sets LSP packet retransmission internal.
6	ZXR10(config-if-vlanX)#**isis priority** <*priority*>[**level-1**|**level-2**]	This designates DIS election priority of an interface.
7	ZXR10(config-if-vlanX)#**isis metric** <*metric-value*>[**level-1**|**level-2**]	This configures IS-IS metric of an interface to participate in calculation for number of shortest IS-IS paths.
8	ZXR10(config-if-vlanX)#**isis csnp-interval** <*interval*>[**level-1**|**level-2**]	This configures IS-IS CSNP interval in order to set the interval between CSNP packets.

Configuring IS-IS Authentication

ZXR10 5900/5200 supports plain text authentication and MD5 encryption authentication.

Step	Command	Function
1	ZXR10(config-if-vlanX)#**isis authentication-type** {**text**|**md5**}[**level-1**|**level-2**]	This sets the authentication method for an interface.
2	ZXR10(config-router)#**authentication-type** {**text**|**md5**}[**level-1**|**level-2**]	This sets the authentication method for LSP packets.

For each authentication mode ZXR10 5900/5200 supports three type authentication modes

Step	Command	Function
1	ZXR10(config-if-vlanX)#**isis authentication**<*key*>[**level-1**|**level-2**]	This sets interface authentication.
2	ZXR10(config-router)#**authentication**<*key*>[**level-1**|**level-2**]	This sets LSP authentication.
3	ZXR10(config-router)#**enable-snp-authentication**	This sets SNP authentication.

Configure SNP authentication, and the authentication character string is "welcome".

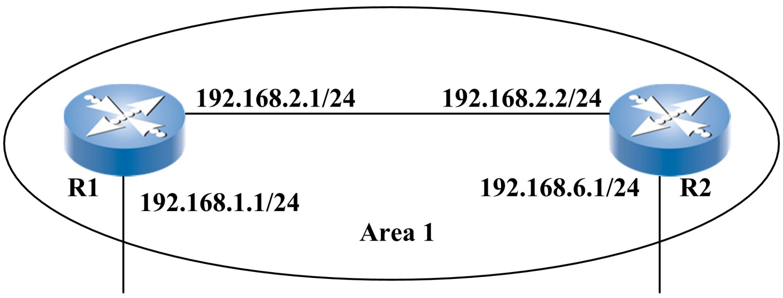
```
ZXR10(config)#router isis
ZXR10(config-router)#authentication welcome
ZXR10(config-router)#enable-snp-authentication
```

IS-IS Configuration Example

Single Area IS-IS Configuration

Before configuring IS-IS, it is necessary to analyze whole network, plan network topology and to decide whether it is necessary to divide the network into areas or not. Run multiple routing protocols on the network according to the network size. The following example shows the basic configuration of IS-IS on a single-area network. This is shown in Figure 11.

FIGURE 11 SINGLE AREA CONFIGURATION



In the above figure, R1 and R2 form Area 1 and they run IS-IS.

R1 configuration:

```
ZXR10_R1(config)#router isis
ZXR10_R1(config-router)#area 01
ZXR10_R1(config-router)#system-id 00D0.D0C7.53E0
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#interface vlan4
ZXR10_R1(config-if-vlan4)#ip address 192.168.2.1 255.255.255.0
ZXR10_R1(config-if-vlan4)#ip router isis
ZXR10_R1(config)#interface vlan6
ZXR10_R1(config-if-vlan6)#ip address 192.168.1.1 255.255.255.0
ZXR10_R1(config-if-vlan6)#ip router isis
```

R2 configuration:

```
ZXR10_R2(config)#router isis
ZXR10_R2(config-router)#area 01
ZXR10_R2(config-router)#system-id 00D0.D0C7.5460
ZXR10_R2(config-router)#exit
ZXR10_R2(config)#interface vlan4
ZXR10_R2(config-if-vlan4)#ip address 192.168.2.2 255.255.255.0
ZXR10_R2(config-if-vlan4)#ip router isis
ZXR10_R2(config)#interface vlan3
ZXR10_R2(config-if-vlan3)#ip address 192.168.6.1 255.255.255.0
ZXR10_R2(config-if-vlan3)#ip router isis
```

The result is viewed as follows:

```
ZXR10_R1(config#show isis adjacency
Interface      System id      State  Lev  Holds  SNPA(802.2)    Pri     MT
vlan8          ZXR10          UP/UP  L1L2 28/28  0000.1000.0009 64/64

ZXR10_R1(config#show ip route
IPv4 Routing Table:
Dest            Mask            Gw              Interface     Owner   Pri Metric
10.1.1.0        255.255.255.0   10.1.1.2        vlan10        direct  0   0
10.1.1.2        255.255.255.255 10.1.1.2        vlan10        address 0   0
192.168.1.0     255.255.255.0   192.168.1.1     vlan24        direct  0   0
192.168.1.1     255.255.255.255 192.168.1.1     vlan24        address 0   0
192.168.2.0     255.255.255.0   192.168.2.1     vlan8         direct  0   0
192.168.2.1     255.255.255.255 192.168.2.1     vlan8         address 0   0
192.168.6.0     255.255.255.0   192.168.2.2     vlan8         isis-l1 115 20
```

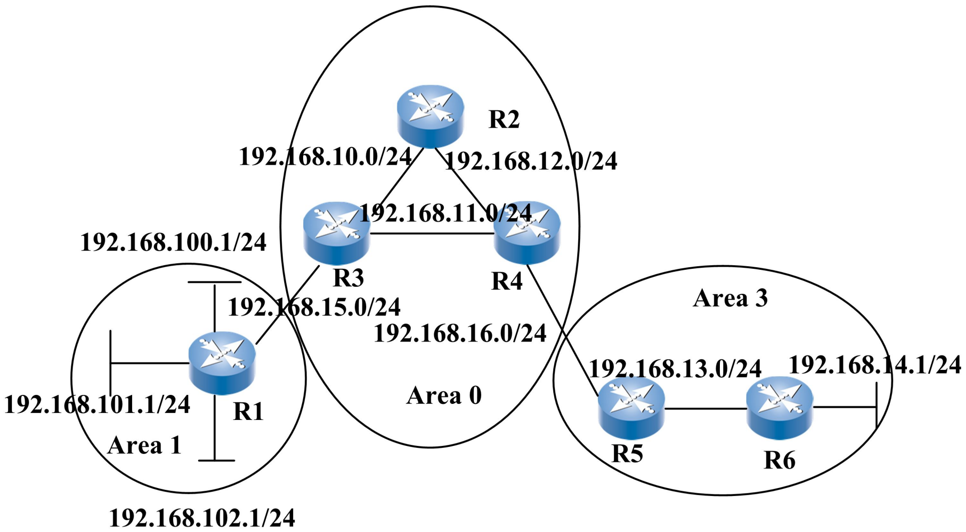
```
ZXR10_R2(config)#show isis adjacency
Interface      System id      State  Lev  Holds  SNPA(802.2)    Pri     MT
vlan8          ZXR10          UP/UP  L1L2 8/8    0019.8310.2321 64/64
```

```
ZXR10_R2(config)#show ip route
IPv4 Routing Table:
Dest            Mask            Gw              Interface     Owner   pri metric
10.1.1.0        255.255.255.0   10.1.1.3        vlan1         direct  0   0
10.1.1.3        255.255.255.255 10.1.1.3        vlan1         address 0   0
192.168.1.0     255.255.255.0   192.168.2.1     vlan8         isis-l1 115 20
192.168.2.0     255.255.255.0   192.168.2.2     vlan8         direct  0   0
192.168.2.2     255.255.255.255 192.168.2.2     vlan8         address 0   0
192.168.6.0     255.255.255.0   192.168.6.1     vlan24        direct  0   0
192.168.6.1     255.255.255.255 192.168.6.1     vlan24        address 0   0
```

Multiple Area IS-IS Configuration

If a network is large, then divide IS-IS network into multiple areas. Routers in a geographic area or of similar functions can be put into one area. This reduces the demand on memory. Routers in an area only need to maintain a small link state database. This is shown inFigure 12.

FIGURE 12 MULTIPLE AREA IS-IS CONFIGURATION



R1 is in Area 1. R2, R3, and R4 are in Area 0. R5 and R6 are in Area 2. Segments in Area 1 are aggregated on R1. The default route is redistributed to IS-IS on R6.

R1 configuration:

```
ZXR10_R1(config)#router isis
ZXR10_R1(config-router)#area 01
ZXR10_R1(config-router)#system-id 00D0.D0C7.53E0
ZXR10_R1(config-router)#is-type LEVEL-1-2
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#interface vlan4
ZXR10_R1(config-if-vlan4)#ip address 192.168.15.1 255.255.255.0
ZXR10_R1(config-if-vlan4)#ip router isis
ZXR10_R1(config-if-vlan4)#isis circuit-type LEVEL-2
ZXR10_R1(config-if-vlan4)#exit
ZXR10_R1(config)#interface vlan6
ZXR10_R1(config-if-vlan6)#ip address 192.168.100.1 255.255.255.0
ZXR10_R1(config-if-vlan6)#ip router isis
ZXR10_R1(config-if-vlan6)#isis circuit-type LEVEL-1
ZXR10_R1(config-if-vlan6)#exit
ZXR10_R1(config)#interface vlan7
ZXR10_R1(config-if-vlan7)#ip address 192.168.101.1 255.255.255.0
ZXR10_R1(config-if-vlan7)#ip router isis
ZXR10_R1(config-if-vlan7)#isis circuit-type LEVEL-1
ZXR10_R1(config-if-vlan7)#exit
ZXR10_R1(config)#interface vlan8
ZXR10_R1(config-if-vlan8)#ip address 192.168.102.1 255.255.255.0
ZXR10_R1(config-if-vlan8)#ip router isis
ZXR10_R1(config-if-vlan8)#isis circuit-type LEVEL-1
ZXR10_R1(config-if-vlan8)#exit
ZXR10_R1(config)#router isis
ZXR10_R1(config-router)#summary-address 192.168.100.0 255.255.252.0 metric 10
```

R2 configuration:

```
ZXR10_R2(config)#router isis
ZXR10_R2(config-router)#area 00
ZXR10_R2(config-router)#system-id 00D0.E0D7.53E0
ZXR10_R2(config-router)#is-type LEVEL-2
ZXR10_R2(config-router)#exit
ZXR10_R2(config)#interface vlan4
ZXR10_R2(config-if-vlan4)#ip address 192.168.10.2 255.255.255.0
ZXR10_R2(config-if-vlan4)#ip router isis
ZXR10_R2(config-if-vlan4)#isis circuit-type LEVEL-2
ZXR10_R2(config-if-vlan4)#exit
ZXR10_R2(config)#interface vlan6
ZXR10_R2(config-if-vlan6)#ip address 192.168.12.2 255.255.255.0
ZXR10_R2(config-if-vlan6)#ip router isis
ZXR10_R2(config-if-vlan6)#isis circuit-type LEVEL-2
ZXR10_R2(config-if-vlan6)#exit
```

R3 configuration:

```
ZXR10_R3(config)#router isis
ZXR10_R3(config-router)#area 00
ZXR10_R3(config-router)#system-id 00D0.E0C7.53E0
ZXR10_R3(config-router)#is-type LEVEL-2
ZXR10_R3(config-router)#exit
ZXR10_R3(config)#interface vlan4
ZXR10_R3(config-if-vlan4)#ip address 192.168.15.3 255.255.255.0
ZXR10_R3(config-if-vlan4)#ip router isis
ZXR10_R3(config-if-vlan4)#isis circuit-type LEVEL-2
ZXR10_R3(config-if-vlan4)#exit
ZXR10_R3(config)#interface vlan6
ZXR10_R3(config-if-vlan6)#ip address 192.168.10.3 255.255.255.0
ZXR10_R3(config-if-vlan6)#ip router isis
ZXR10_R3(config-if-vlan6)#isis circuit-type LEVEL-2
ZXR10_R3(config)#interface vlan7
ZXR10_R3(config-if-vlan7)#ip address 192.168.11.3 255.255.255.0
ZXR10_R3(config-if-vlan7)#ip router isis
ZXR10_R3(config-if-vlan7)#isis circuit-type LEVEL-2
ZXR10_R3(config-if-vlan7)#exit
```

R4 configuration:

```
ZXR10_R4(config)#router isis
ZXR10_R4(config-router)#area 00
ZXR10_R4(config-router)#system-id 00D0.E0E7.53E0
ZXR10_R4(config-router)#is-type LEVEL-2
ZXR10_R4(config-router)#exit
ZXR10_R4(config)#interface vlan4
ZXR10_R4(config-if-vlan4)#ip address 192.168.12.4 255.255.255.0
ZXR10_R4(config-if-vlan4)#ip router isis
ZXR10_R4(config-if-vlan4)#isis circuit-type LEVEL-2
ZXR10_R4(config-if-vlan4)#exit
ZXR10_R4(config)#interface vlan6
ZXR10_R4(config-if-vlan6)#ip address 192.168.11.4 255.255.255.0
ZXR10_R4(config-if-vlan6)#ip router isis
ZXR10_R4(config-if-vlan6)#isis circuit-type LEVEL-2
ZXR10_R4(config-if-vlan6)#exit
ZXR10_R4(config)#interface vlan7
ZXR10_R4(config-if-vlan7)#ip address 192.168.16.4 255.255.255.0
ZXR10_R4(config-if-vlan7)#ip router isis
ZXR10_R4(config-if-vlan7)#isis circuit-type LEVEL-2
ZXR10_R4(config-if-vlan7)#exit
```

R5 configuration:

```
ZXR10_R5(config)#router isis
ZXR10_R5(config-router)#area 02
ZXR10_R5(config-router)#system-id 00D0.D0CF.53E0
ZXR10_R5(config-router)#is-type LEVEL-1-2
ZXR10_R5(config-router)#exit
ZXR10_R5(config)#interface vlan4
ZXR10_R5(config-if-vlan4)#ip address 192.168.16.5 255.255.255.0
ZXR10_R5(config-if-vlan4)#ip router isis
ZXR10_R5(config-if-vlan4)#isis circuit-type LEVEL-2
ZXR10_R5(config-if-vlan4)#exit
```

```
ZXR10_R5(config)#interface vlan6
ZXR10_R5(config-if-vlan6)#ip address 192.168.13.5 255.255.255.0
ZXR10_R5(config-if-vlan6)#ip router isis
ZXR10_R5(config-if-vlan6)#isis circuit-type LEVEL-1
ZXR10_R5(config-if-vlan6)#exit
```

R6 configuration:

```
ZXR10_R6(config)#router isis
ZXR10_R6(config-router)#area 02
ZXR10_R6(config-router)#system-id 00D0.0ECD.53E0
ZXR10_R6(config-router)#is-type LEVEL-1
ZXR10_R6(config-router)#exit
ZXR10_R6(config)#interface vlan4
ZXR10_R6(config-if-vlan4)#ip address 192.168.13.6 255.255.255.0
ZXR10_R6(config-if-vlan4)#ip router isis
ZXR10_R6(config-if-vlan4)#isis circuit-type LEVEL-1
ZXR10_R6(config-if-vlan4)#exit
ZXR10_R6(config)#interface vlan8
ZXR10_R6(config-if-vlan8)#ip address 192.168.14.1 255.255.255.0
ZXR10_R6(config-if-vlan8)#exit
ZXR10_R6(config)#ip route 0.0.0.0 0.0.0.0 192.168.13.5
ZXR10_R6(config)#router isis
ZXR10_R6(config-router)#default-information originate
ZXR10_R6(config-router)#redistribute static metric 10
ZXR10_R6(config-router)#end
```

IS-IS Maintenance and Diagnosis

ZXR10 5900/5200 provides **show** command for maintenance and diagnosis.

Step	Command	Function
1	ZXR10#**show isis adjacency** [**level-1**|**level-2**]	This views the current adjacency.
2	ZXR10#**show isis circuits** [**detail**]	This displays the information of the current IS-IS interface.
3	ZXR10#**show isis database** [**level-1**|**level-2**][**detail**]	This views the information of the current IS-IS database.
4	ZXR10#**show isis topology** [**level-1**|**level-2**]	This shows the current IS-IS topology.
5	ZXR10#**show ip route** [**isis-l1**|**isis-l2**]	This views global routing table and check if IS-IS route is in this route.
6	ZXR10#**show ip forwarding subnetrt** <*ip-address*><*net -mask*>	This views driving hardware routing table and check if hardware routing table is same as global routing table.

ZXR10 5900/5200 also provides **debug** command for maintenance and diagnosis.

Step	Command	Function
1	`ZXR10#`**debug isis adj-packets**	This tracks and shows the received transmission of IS-IS Hello packets.
2	`ZXR10#`**debug isis snp-packets**	This tracks and views the SNP packets which IS-IS receives and sends and related handling event.
3	`ZXR10#`**debug isis spf-events**	This tracks and views the debugging information of IS-IS route calculation event.
4	`ZXR10#`**debug isis nsf-event**	This tracks and views the debugging information of the IS-IS LSP processing event.

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Chapter 5

BGP Configuration

Table of Contents

BGP Overview 45
Configuring BGP 46
BGP Configuration Example...61
BGP Maintenance and Diagnosis 63

BGP Overview

Border Gateway Protocol (BGP) is an inter-area routing protocol. BGP exchanges Network Layer Reachable Information (NLRI) between ASs that run BGP. This information includes a list of the ASs that the routes pass. They are enough for creating a diagram indicating the AS connection state. This makes the AS-based routing policy possible and solves the route loop problem.

BGP Version 4 (BGP4), defined in RFC1771, supports CIDR, supernet, subnet, route aggregation, and route filtering, and is widely used on the Internet currently.

Border Gateway Protocol (BGP) is an interautonomous system routing protocol. An autonomous system is a network or group of networks under a common administration and with common routing policies.

BGP is used to exchange routing information for the Internet and is the protocol used between Internet service providers (ISP). Customer networks, such as universities and corporations, usually employ an Interior Gateway Protocol (IGP) such as RIP or OSPF for the exchange of routing information within their networks. Customers connect to ISPs, and ISPs use BGP to exchange customer and ISP routes. When BGP is used between autonomous systems (AS), the protocol is referred to as External BGP (EBGP). If a service provider is using BGP to exchange routes within an AS, then the protocol is referred to as Interior BGP (IBGP).

AS indicator is a 16-bit value ranging from 1 to 65535 of which the numbers from 1 to 32767 are available for allocation. Those from 32768 to 64511 are reserved. Those from 64512 to 65534 are used for private ASs (similar to private network addresses in IP addresses).

BGP runs on the basis of a reliable transfer protocol with TCP as its underlying protocol and TCP port 179. Routers running BGP first set up a TCP connection and then exchange all the routing table information after authentication. After that when the routing table

changes. They send route update messages to all BGP neighbors who will further spread the routing information until it reaches the whole network.

Routes learned via BGP have associated properties that are used to determine the best route to a destination when multiple paths exist to a particular destination. These properties are referred to as BGP attributes. There are four types of path attributes:

1. Mandatory AttributeIt must appear in the route description.

   AS-path

   Next hop

   Origin
2. Self-Defined AttributeIt does not have to appear in the route description.

   Local preference

   Atomic aggregate
3. Optional Transitional AttributeIt does not have to be supported by all BGP implementations. If it is supported, it can be forwarded to BGP neighbors. If it is not supported by the current router, it should be forwarded to other BGP routers.

   Aggregator

   Community
4. Optional Non-Transitional AttributeIt should be deleted by the routers that do not support it.

   Multi-exit-discriminator (MED)

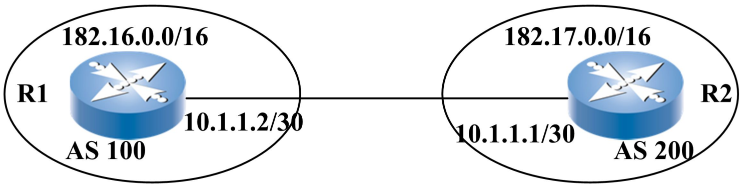
Configuring BGP

Enabling BGP

Step	Command	Function
1	`ZXR10(config)#`**router bgp** <*as-number*>	This starts the BGP process.
2	`ZXR10(config-router)#`**neighbor** <*ip-address*> **remote-as** <*number*>	This configures BGP neighbors.
3	`ZXR10(config-router)#` **network** <*ip-address*><*net-mask*>	This configures BGP to advertise a network.

Example R1 is in AS 100 and R2 in AS 200. This is shown in Figure 13.

FIGURE 13 BASIC BGP CONFIGURATION



R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 10.1.1.1 remote-as 200
ZXR10_R1(config-router)#network 182.16.0.0 255.255.0.0
```

R2 configuration:

```
ZXR10_R2(config)#router bgp 200
ZXR10_R2(config-router)#neighbor 10.1.1.2 remote-as 100
ZXR10_R2(config-router)#network 182.17.0.0 255.255.0.0
```

In the above configuration, R1 and R2 define each other as BGP neighbor. R1 and R2 belong to different Ass. They will set up an EBGP session. R1 advertises network 182.16.0.0/16 and R2 advertises network 182.17.0.0/16.

The result is viewed as follows:

```
ZXR10_R1(config)#show ip route
IPv4 Routing Table:
Dest            Mask            Gw              Interface     Owner   Pri Metric
10.0.1.0        255.255.255.252 10.0.1.2        vlan8         direct  0   0
10.0.1.2        255.255.255.255 10.0.1.2        vlan8         address 0   0
10.1.1.0        255.255.255.0   10.1.1.2        vlan10        direct  0   0
10.1.1.2        255.255.255.255 10.1.1.2        vlan10        address 0   0
182.16.0.0      255.255.0.0     182.16.1.1      vlan24        direct  0   0
182.16.1.1      255.255.255.255 182.16.1.1      vlan24        address 0   0
182.17.0.0      255.255.0.0     10.0.1.1        vlan8         bgp     20  0
```

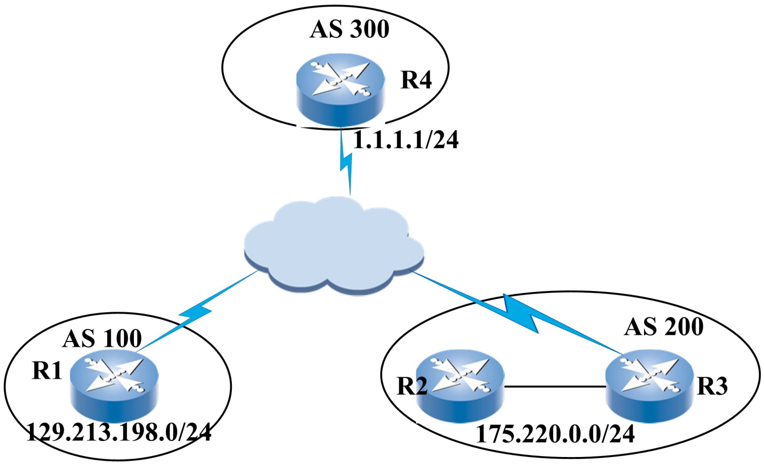
```
ZXR10_R2(config)#show ip route
IPv4 Routing Table:
Dest            Mask            Gw              Interface     Owner   pri metric
10.0.1.0        255.255.255.252 10.0.1.1        vlan8         direct  0   0
10.0.1.1        255.255.255.255 10.0.1.1        vlan8         address 0   0
10.1.1.0        255.255.255.0   10.1.1.3        vlan1         direct  0   0
10.1.1.3        255.255.255.255 10.1.1.3        vlan1         address 0   0
182.16.0.0      255.255.0.0     10.0.1.2        vlan8         bgp     20  0
182.17.0.0      255.255.0.0     182.17.1.1      vlan24        direct  0   0
182.17.1.1      255.255.255.255 182.17.1.1      vlan24        address 0   0
```

Configuring BGP Route Advertisement

Step	Command	Function
1	`ZXR10(config-router)#`**network**	This advertises network directly connected to the current router.
2	`ZXR10(config-router)#`**redistribute** <*protocol*>[**metric** <*metric-value*>][**route-map** <*map-tag*>]	This redistributes the routes learnt by other routing protocols to BGP.

Example Figure 14 shows an example of advertising routes to BGP by re-distribution.

FIGURE 14 BGP ROUTE ADVERTISEMENT



R3 configuration:

```
ZXR10_R3(config)#router ospf 1
ZXR10_R3(config-router)#network 175.220.0.0 0.0.0.255 area 0
ZXR10_R3(config)#router bgp 200
ZXR10_R3(config-router)#neighbor 1.1.1.1 remote-as 300
ZXR10_R3(config-router)#redistribute ospf
```

Configuring BGP Aggregate Advertisement

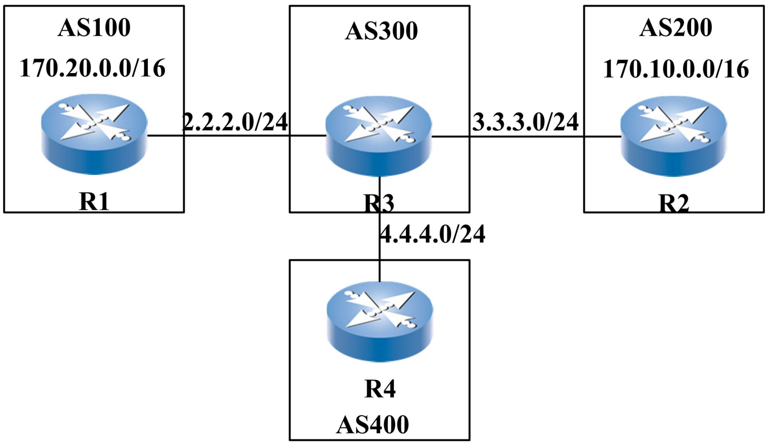
This section describes that BGP can aggregate multiple learnt routes to one route and advertise it. These entries in a routing table can be significantly reduced.

Command	Function
ZXR10(config-router)#**aggregate-address** <*ip-address*><*net-mask*>[**count** <*count*>][**as-set**][**summary-only**][**strict**]	This creates an aggregate policy in the BGP routing table.

Example R1 and R2 advertise routes 170.20.0.0/16 and 170.10.0.0/16 respectively.

R3 aggregates the two routes into 170.0.0.0/8 and advertises it to R4. After route aggregate is configured, R4's routing table can only learn the aggregate route 170.0.0.0/8. This is shown in Figure 3.

FIGURE 15 BGP AGGREGATE ADVERTISEMENT



R1 configuration:

```
ZXR10_R1(config)#interface vlan1
ZXR10_R1(config-if-vlan1)#ip address 2.2.2.2 255.255.255.0
ZXR10_R1(config-if-vlan1)#exit
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#network 170.20.0.0 255.255.0.0
ZXR10_R1(config-router)#neighbor 2.2.2.1 remote-as 300
```

R2 configuration:

```
ZXR10_R2(config)#interface vlan1
ZXR10_R2(config-if-vlan1)#ip address 3.3.3.3 255.255.255.0
ZXR10_R2(config-if-vlan1)#exit
ZXR10_R2(config)#router bgp 200
ZXR10_R2(config-router)#network 170.10.0.0 255.255.0.0
ZXR10_R2(config-router)#neighbor 3.3.3.1 remote-as 300
```

R3 configuration:

```
ZXR10_R3(config)#interface vlan1
ZXR10_R3(config-if-vlan1)#ip address 2.2.2.1 255.255.255.0
ZXR10_R3(config-if-vlan1)#exit
ZXR10_R3(config)#interface vlan2
ZXR10_R3(config-if-vlan2)#ip address 3.3.3.1 255.255.255.0
ZXR10_R3(config-if-vlan2)#exit
ZXR10_R3(config)#interface vlan3
ZXR10_R3(config-if-vlan3)#ip address 4.4.4.1 255.255.255.0
ZXR10_R3(config-if-vlan3)#exit
ZXR10_R3(config)#router bgp 300
ZXR10_R3(config-router)#neighbor 2.2.2.2 remote-as 100
ZXR10_R3(config-router)#neighbor 3.3.3.3 remote-as 200
ZXR10_R3(config-router)#neighbor 4.4.4.4 remote-as 400
ZXR10_R3(config-router)# aggregate-address 170.0.0.0 255.0.0.0
```

```
summary-only count 0
```

R3 learns both routes 170.20.0.0 and 170.10.0.0 but it only advertises the aggregate route 170.0.0.0/8. Pay attention to the parameter summary-only in the command. Without that parameter, R3 will advertise both routes in addition to the aggregate route.

R4 configuration:

```
ZXR10_R4(config)#interface vlan1
ZXR10_R4(config-if-vlan1)#ip address 4.4.4.4 255.255.255.0
ZXR10_R4(config-if-vlan1)#exit
ZXR10_R4(config)#router bgp 400
ZXR10_R4(config-router)#neighbor 4.4.4.1 remote-as 300
```

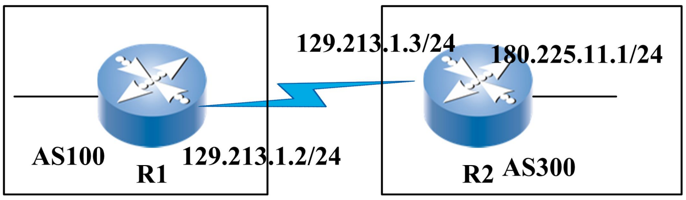
Configuring Multihop in EBGP

EBGP neighbor is established on the interfaces directly connecting two routers. If EBGP neighbor is to be established on indirectly-connected interfaces, neighbor ebgp-multihop command is used in order to perform EBGP multihop configuration. It is suitable for IGP or static routing configuration to enable indirectly-connected neighbors to communicate with each other. This section describes the EBGP neighbor to establish on indirectly-connected interfaces.

Command	Function
ZXR10(config-router)#**neighbor** *<ip-address>* **ebgp-multihop** [**ttl** *<value>*]	This configures EBGP neighbors on indirectly-connected interface

Example R1 needs to set up the adjacency relationship with the indirectly-connected interface 180.225.11.1 on R2. **Neighbor ebgp-multi hop** command is configured. This is shown in Figure 16.

FIGURE 16 CONFIGURATION OF BGP MULTIHOP



R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 180.225.11.1 remote-as 300
ZXR10_R1(config-router)#neighbor 180.225.11.1 ebgp-multihop
```

R2 configuration:

```
ZXR10_R2(config)#router bgp 300
ZXR10_R2(config-router)#neighbor 129.213.1.2 remote-as 100
```

Filtering Routes by Router

Route filtering and attributes are the basis of BGP decision. Route filtering allows controlling the attributes of the imported and exported routes based on needs.

Route map is used to control the routing information and redistribute routes between areas by defining conditions. Route map usually works with route attributes to allow making decisions on routes.

Step	Command	Function
1	ZXR10(config)#**route-map** *<map-tag>*[**permit**|**deny**][*<sequence-number>*]	This defines a route map
2	ZXR10(config-router)#**neighbor** *<ip-address>* **route-map** *<map-tag>*{**in**|**out**}	This filters the routes advertised or being advertised to neighbors.

Example To configure routes filtering by routers, an example is given below:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 182.17.20.1 remote-as 200
ZXR10_R1(config-router)#neighbor 182.17.20.1 route-map MAP1 out
ZXR10_R1(config-router)#neighbor 182.17.20.1 send-med
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#route-map MAP1 permit 10
ZXR10_R1(config-route-map)#match ip address 1
ZXR10_R1(config-route-map)#set metric 5
ZXR10_R1(config-route-map)#exit
ZXR10_R1(config)#acl standard number 1
ZXR10_R1(config-std-acl)#rule 1 permit 172.3.0.0 0.0.255.255
```

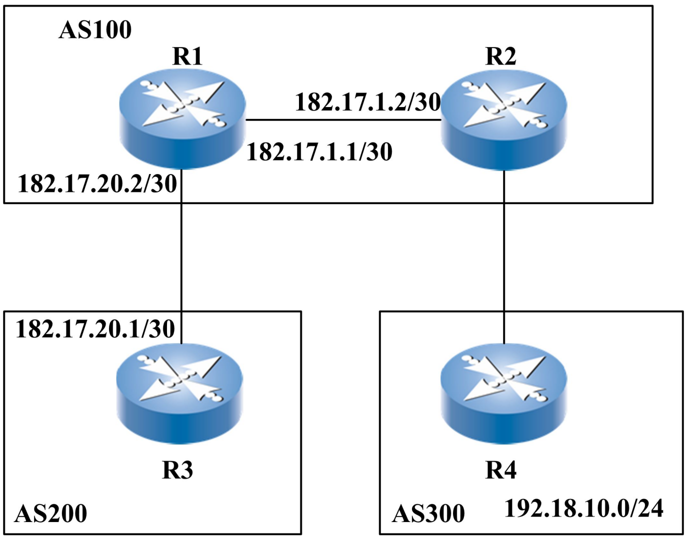
MAP1 is a router defined in above example. Its route map allows the network 172.3.0.0 to be advertised to AS 200 and sets its MED to 5. The route map is often used with match and set command. Match command defines the match conditions. Set command defines action to be executed when match conditions are met by match command.

Filtering Routes Using NLRI

To set limit to a router when it gets or advertises the routing information. The route updates can be filtered from or destined for a particular neighbor. The filter has an update list of the neighbors where the route updates are from or destined for.

Example R1 and R2 are IBGP peers. R1 and R3 are EBGP peers. R2 and R4 are EBGP peers. This is shown in Figure 17.

FIGURE 17 FILTERING ROUTES USING NLRI



Avoid AS100 from being a transitional AS and advertise the network 192.18.10.0/24 from AS300 to AS200. Filtering on R1 is performed.

The configuration on R1 is shown below.

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#no synchronization
ZXR10_R1(config-router)#neighbor 182.17.1.2  remote-as 100
ZXR10_R1(config-router)#neighbor 182.17.20.1  remote-as 200
ZXR10_R1(config-router)#neighbor 182.17.20.1  route-map MAP1 out
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#route-map MAP1 permit 10
ZXR10_R1(config-route-map)#match ip address 1
ZXR10_R1(config-route-map)#exit
ZXR10_R1(config)#acl standard number 1
ZXR10_R1(config-std-acl)#rule 1 deny 192.18.10.0 0.0.0.255
ZXR10_R1(config-std-acl)#rule 2 permit any
```

To prevent R1 from transmitting the prefix 192.18.10.0/24 to AS200, **route-map** command and ACL is used.

Filtering Route Based on AS_PATH

When all routes in one or multiple ASs need to be filtered, AS path-based route filtering is used. It avoids the complexity caused by prefix filtering.

To set a new ACL for imported and exported updates based on AS paths, use the following command.

Command	Function
ZXR10(config)#**ip as-path access-list** *<acl-number>*{**permit**|**deny**}*<as-regular-expression>*	This sets a new ACL.

Use the route filtration based on AS path to prevent R1 from advertising the network 192.18.10.0/24 to AS200.

The configuration is shown below.

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#no synchronization
ZXR10_R1(config-router)#neighbor 182.17.1.2  remote-as 100
ZXR10_R1(config-router)#neighbor 182.17.20.1  remote-as 200
ZXR10_R1(config-router)#neighbor 182.17.20.1  route-map MAP1 out
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#route-map MAP1 permit 10
ZXR10_R1(config-route-map)#match as-path 1
ZXR10_R1(config-route-map)#exit
ZXR10_R1(config)#ip as-path access-list 1 permit ^$
```

In this configuration, the list is accessed through AS paths, which makes R1 advertise only the networks from AS100 to AS200, so that the network 192.18.10.0/24 can be filtered.

Setting LOCAL_PREF Attribute

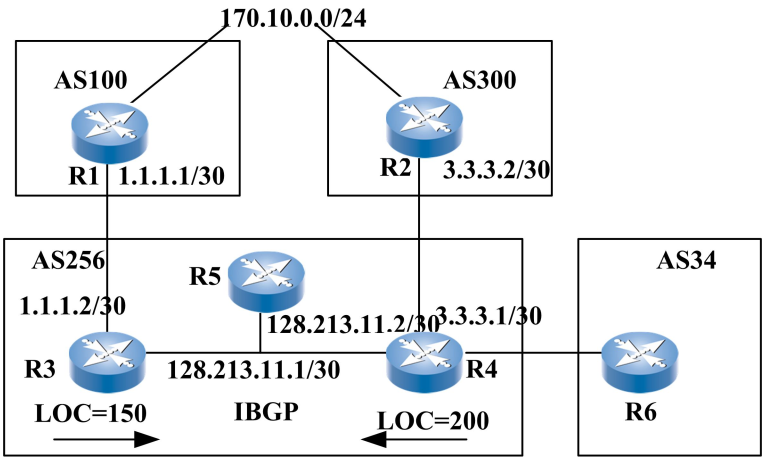
Value of the Local preference attribute is used for routing between the IBGP peers inside an AS.

To set the local preference value of the BGP advertised routes, use the following command.

Command	Function
ZXR10(config-router)#**bgp default local-preference** *<value>*	This sets the local preference value of the BGP advertised routes.

R3 and R4 synchronously learn the route to 170.10.0.0. Local preference value of R4 is greater; packets from AS256 to the destination are passed to R4. This is shown in Figure 18.

FIGURE 18 LOCAL_PREF ATTRIBUTE



The following two modes are used to configure the LOCAL_PREF attribute.

1. Set the LOCAL_PREF attribute with the **BGP default local-preference** command.

   R3 configuration:

```
ZXR10_R3(config)#router bgp 256
ZXR10_R3(config-router)#neighbor 1.1.1.1 remote-as 100
ZXR10_R3(config-router)#neighbor 128.213.11.2 remote-as 256
ZXR10_R3(config-router)#bgp default local-preference 150
```

   R4 configuration:

```
ZXR10_R4(config)#router bgp 256
ZXR10_R4(config-router)#neighbor 3.3.3.2 remote-as 300
ZXR10_R4(config-router)#neighbor 128.213.11.1 remote-as 256
ZXR10_R4(config-router)#bgp default local-preference 200
```

2. Set the LOCAL_PREF attribute with the **route-map**command.

   R4 configuration:

```
ZXR10_R4(config)#router bgp 256
ZXR10_R4(config-router)#neighbor 3.3.3.2 remote-as 300
ZXR10_R4(config-router)#neighbor 3.3.3.2 route-map setlocalin in
ZXR10_R4(config-router)#neighbor 128.213.11.1 remote-as 256
....
ZXR10_R4(config)#ip as-path access-list 7 permit ^300$
...
ZXR10_R4(config)#route-map setlocalin permit 10
ZXR10_R4(config-route-map)#match as-path 7
ZXR10_R4(config-route-map)#set local-preference 200
ZXR10_R4(config-route-map)#exit
ZXR10_R4(config)#route-map setlocalin permit 20
ZXR10_R4(config-route-map)#set local-preference 150
```

Setting MED Attribute

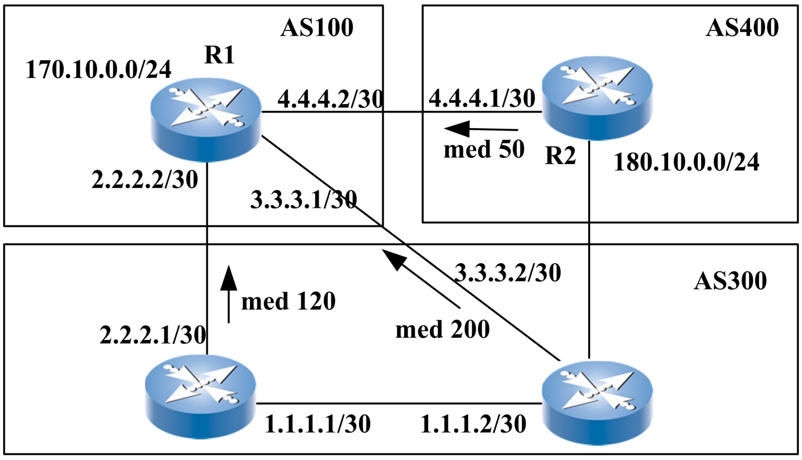
Metric attribute is also called the Multi_Exit_Discrimination attribute (MED) .Router only compares the adjacent Metric value of the BGP from the same AS by default. If comparing adjacent Metric values of neighbors from different ASs, execute necessarily the MED attribute command to forcefully compare them.

To configure the Metric values of neighbors from different As, use the **bgp always-compare-med** command.

R1 synchronously receives the 180.10.0.0 update from R2, R3 and R4. Only compare the Metric values of the adjacent R3 and R4 from the same AS by default.

Metric value of the R3 is smaller than that of the R4. Therefore, for the 180.10.0.0 update, the R1 preferentially uses the R3. This is shown in Figure 19.

FIGURE 19 MED ATTRIBUTE



The following is to set the MED value with the route-map command.

R3 configuration:

```
ZXR10_R3(config)#router bgp 300
ZXR10_R3(config-router)#neighbor 2.2.2.2 remote-as 100
ZXR10_R3(config-router)#neighbor 2.2.2.2 send-med
ZXR10_R3(config-router)#neighbor 2.2.2.2 route-map setmetricout out
ZXR10_R3(config-router)#neighbor 1.1.1.2 remote-as 300
ZXR10_R3(config-router)#exit
ZXR10_R3(config)#route-map setmetricout permit 10
ZXR10_R3(config-route-map)#set metric 120
```

R4 configuration:

```
ZXR10_R4(config)#router bgp 300
ZXR10_R4(config-router)#neighbor 3.3.3.1 remote-as 100
ZXR10_R4(config-router)#neighbor 3.3.3.1 send-med
ZXR10_R4(config-router)#neighbor 3.3.3.1 route-map setmetricout out
ZXR10_R4(config-router)#neighbor 1.1.1.1 remote-as 300
ZXR10_R4(config-router)#exit
ZXR10_R4(config)#route-map setmetricout permit 10
ZXR10_R4(config-route-map)#set metric 200
```

R2 configuration:

```
ZXR10_R2(config)#router bgp 400
ZXR10_R2(config-router)#neighbor 4.4.4.2 remote-as 100
ZXR10_R2(config-router)#neighbor 4.4.4.2 send-med
ZXR10_R2(config-router)#neighbor 4.4.4.2 route-map setmetricout out
ZXR10_R2(config-router)#exit
ZXR10_R2(config)#route-map setmetricout permit 10
ZXR10_R2(config-route-map)#set metric 50
```

In the following contents, force R1 to compare the Metric values with the **bgp always-compare-med** command. The Metric value of the R2 is smaller than that of the R3. Therefore, for the 180.10.0.0 update, the R1 selects the R2 rather than the R3.

R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 2.2.2.1 remote-as 300
ZXR10_R1(config-router)#neighbor 3.3.3.2 remote-as 300
ZXR10_R1(config-router)#neighbor 4.4.4.1 remote-as 400
ZXR10_R1(config-router)#bgp always-compare-med
```

Setting Community Attribute

Community attribute is optional transition attribute, with the range from 0 to 4,294,967,200. According to the Community attribute, decisions are made on a group of routes.

Several recognized definitions of the Community attribute as follows:

- No-export: Forbid advertising the neighbors of the EBGP.
- No-advertise: Forbid advertising any neighbors of the BGP.End of steps.
- No-export-subconfed: Forbid advertising the route with the attribute outside the confederation.

Step	Command	Function
1	ZXR10(config)#**route-map**	This defines the Community attribute
2	ZXR10(config-router)#**neighbor** *<ip-address>* **send-community**	This sends the community attribute to neighbor

In the following configuration, the R1 notifies the neighbor to forbid advertising the route 192.166.1.0/24 to other EBGP neighbors.

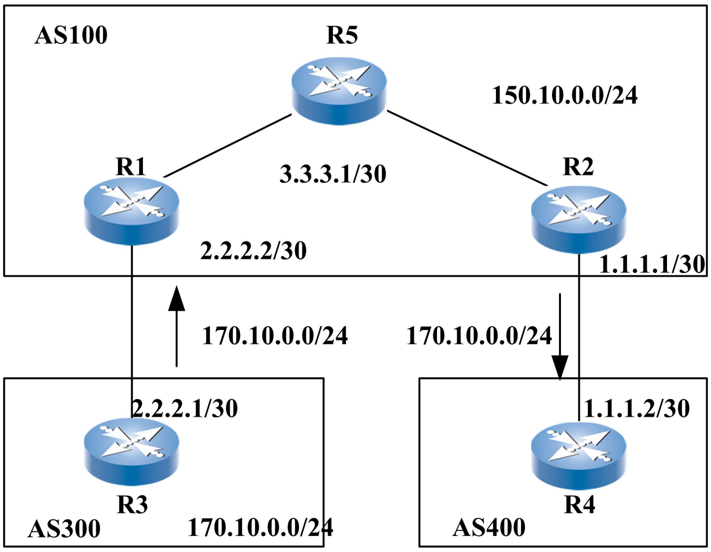
R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 3.3.3.3 remote-as 300
ZXR10_R1(config-router)#neighbor 3.3.3.3 send-community
ZXR10_R1(config-router)#neighbor 3.3.3.3 route-map setcommunityout
ZXR10_R1(config-router)#exit
ZXR10_R1(config)#route-map setcommunity permit 10
ZXR10_R1(config-route-map)#match ip address 1
ZXR10_R1(config-route-map)#set community no-export
ZXR10_R1(config-route-map)#exit
ZXR10_R1(config)#route-map setcommunity permit 20
ZXR10_R1(config-route-map)#exit
ZXR10_R1(config)#acl standard number 1
ZXR10_R1(config-std-acl)#rule 1 permit 192.166.1.0 0.0.0.255
```

Setting BGP Synchronization

In the AS100 both the R1 and the R2 run the IBGP, R5 does not run the BGP. This is shown in Figure 20.

FIGURE 20 BGP SYNCHRONIZATION CONFIGURATION



R2 learns the route 170.10.0.0 through the IBGP. The next-hop is 2.2.2.1. If R2 reaches the 170.10.0.0 then actual next-hop is R5. R5 without the route 170.10.0.0 will throw off the packet. At the moment R2 is also thrown off in R5 if R2 notifies R4 that it has the route 170.10.0.0 itself.

It is necessary to make R5 have the route to the 170.10.0.0 if the packet with the destination of 170.10.0.0 smoothly passes R5 and reaches R3. Therefore route redistribution should be used to help R5 learn the route through IGP. R2 must wait for R2 to learn route by means of the IGP (through R5) before it advertises BGP route to EBGP neighbor. This is called the route synchronization.

Synchronize both the BGP and the IGP with the **synchronization** command.

ZXR10 5900/5200 has booting as its synchronization function by default.

For the transitional AS, the route learned from other AS should be advertised to the third party AS. If the non-BGP route exists inside the AS, the route synchronization should be used. Here R2 adopts route synchronization.

It is unnecessary to use route synchronization when not advertising the BGP route to the third party AS or when the routers inside the As run the BGP.

The following configuration shows how to disable the R2 route synchronization.

```
ZXR10_R2(config)#router bgp 100
ZXR10_R2(config-router)#network 150.10.0.0 255.255.255.0
ZXR10_R2(config-router)#neighbor 1.1.1.2 remote-as 400
ZXR10_R2(config-router)#neighbor 3.3.3.1 remote-as 100
ZXR10_R2(config-router)#no synchronization
```

Setting BGP Router Reflector

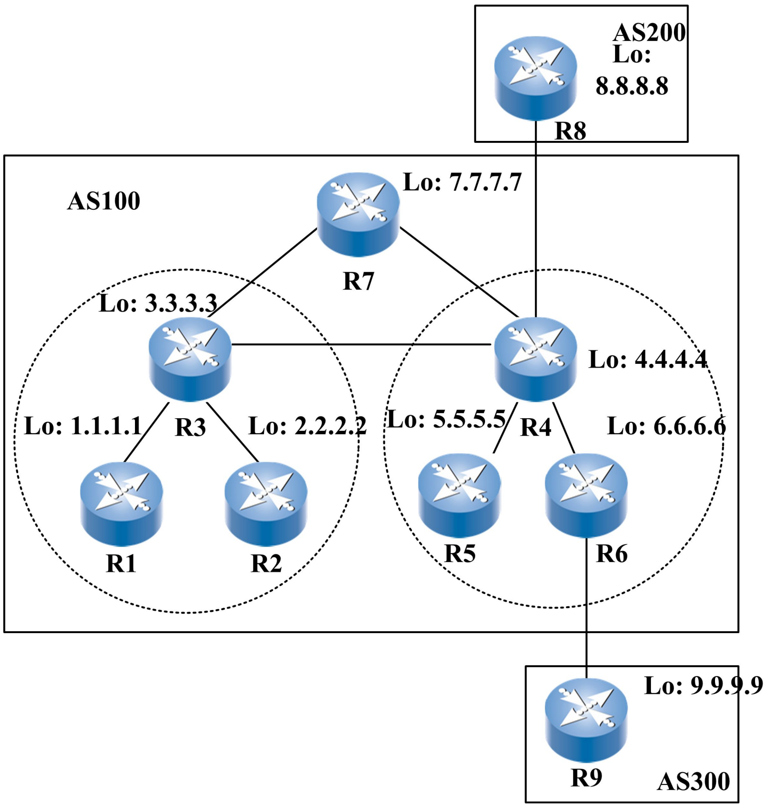
For the BGP routers inside the same AS, the adjacency must be established between every two routers according to requirements and contribute to the formation of all interconnection. As the number of IBP routers increases, the number of neighbors will ascend by n*(n-1)/2 (n refers to the number of the IBGP routers). Router reflector and confederation is used to reduce workload of maintenance and configuration.

Running of IBGP routers inside the AS, select one of preceding routers as Router Reflector (RR). Take other IBGP routers as clients which only establish adjacency with the RR. All clients pass the RR to reflect routes. Thus, the number of neighbors decreases to (n-1).

Set the neighbors as the Router Reflector client peers with the **neighbor** <*ip-address*> **router-refletor-client** command.

AS100 has two router reflectors: R3 and R4. R5 and R6 are the clients of R4. R1 and R2 are the clients of R3. This is shown in Figure 21.

FIGURE 21 BGP ROUTER REFLECTOR CONFIGURATION



R3 configuration:

```
ZXR10_R3(config)#router bgp 100
ZXR10_R3(config-router)#neighbor 2.2.2.2 remote-as 100
ZXR10_R3(config-router)#neighbor 2.2.2.2 route-reflector-client
ZXR10_R3(config-router)#neighbor 1.1.1.1 remote-as 100
ZXR10_R3(config-router)#neighbor 1.1.1.1 route-reflector-client
ZXR10_R3(config-router)#neighbor 7.7.7.7 remote-as 100
```

```
ZXR10_R3(config-router)#neighbor 4.4.4.4 remote-as 100
```

R2 configuration:

```
ZXR10_R2(config)#router bgp 100
ZXR10_R2(config-router)#neighbor 3.3.3.3 remote-as 100
```

When a route is received by the RR, the RR reflects according to types of different peers.

1. If a route comes from non-client peers, it is reflected to all client peers.
2. If a route comes from client peers, it is reflected to all non-client peers and client peers.
3. If a route comes from the EBGP peer, it is reflected to all non-client peers and client peers.

When there are multiple RRs inside an AS, multiple RRs inside an AS are classified as a cluster. There may be multiple clusters inside one AS. A cluster contains more than one RR.

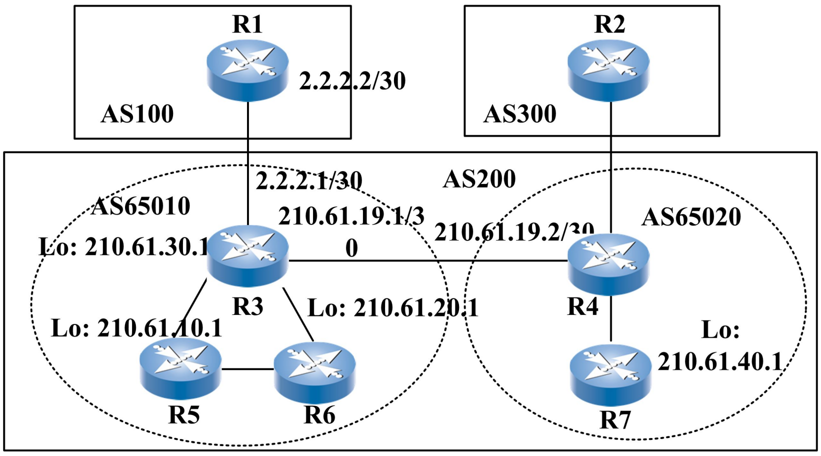
Setting BGP Confederation

Route confederation has the same function as router reflector. The purpose is to reduce the number of IBGP connection neighbors established inside the same AS. Route confederation divides an AS into multiple sub-Ass. Multiple IBGP routers inside AS belongs respectively to the sub-Ass. IBGP is established inside the sub-AS. EBGP is established between sub-ASs. The sub-AS number is called confederation number. For AS outside the sub-AS is invisible.

Step	Command	Function
1	ZXR10(config-router)#**bgp confederation identifier** *<value>*	This sets the confederation ID.
2	ZXR10(config-router)#**bgp confederation peers** *<value>*[**...***<value>*]	This sets the confederation peer AS number.

Example AS200 has five BGP routers. Divide them into two sub-ASs. One is defined as AS65010 containing R3, R5 and R6. The other one is defined as AS65020 containing R4 and R7. This is shown in Figure 22.

FIGURE 22 BGP CONFEDERATION CONFIGURATION



R3 configuration:

```
ZXR10_R3(config)#router bgp 65010
ZXR10_R3(config-router)#bgp confederation identifier 200
ZXR10_R3(config-router)#bgp confederation peers 65020
ZXR10_R3(config-router)#neighbor 210.61.10.1 remote-as 65010
ZXR10_R3(config-router)#neighbor 210.61.20.1 remote-as 65010
ZXR10_R3(config-router)#neighbor 210.61.19.2 remote-as 65020
ZXR10_R3(config-router)#neighbor 2.2.2.2 remote-as 100
```

R5 configuration:

```
ZXR10_R5(config)#router bgp 65010
ZXR10_R5(config-router)#bgp confederation identifier 200
ZXR10_R5(config-router)#neighbor 210.61.30.1 remote-as 65010
ZXR10_R5(config-router)#neighbor 210.61.20.1 remote-as 65010
```

When establishing the adjacency EBGP adjacency between R3 and confederation peers is established. IBGP adjacency in the confederation is established. This adjacency also occurs between R3 and AS100. The AS100 does not know the existence of the confederation so R1 still establishes the adjacency with R3 in AS200.

R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)#neighbor 2.2.2.1 remote-as 200
```

Setting BGP Route Dampening

BGP provides a Route dampening mechanism to reduce the stability caused by Route Flap.

Each time the flap occurs the route is given a penalty of 1000. Route will be suppressed to advertise when the Penalty reaches the Suppress-limit. Each time the half-life-time comes, Penalty exponentially decreases. The suppressed and advertised route will be cancelled when the Penalty decreases to the Reuse-limit.

To make the BGP route damping effective or modify the BGP route damping factors, perform the following steps:

Command	Function
ZXR10(config-router)#**bgp dampening** [*<half-life><reuse><suppress><max-suppress-time>*| **route-map** *<map-tag>*]	This makes the BGP route damping effective or modify the BGP route damping factors.

- Half-life-time: the range is from 1 to 45min and the default value is 15min.
- Reuse-value: the range from 1 to 20000 and the default value is 750.
- Suppress-value: the range from 1 to 20000 and the default value is 2000.
- Max-suppress-time: the range from 1 to 255, four times half-life-time by default.

Example Boot the suppression function in the router:

```
ZXR10(config)#router bgp 100
ZXR10(config-router)#bgp dampening
ZXR10(config-router)#network 203.250.15.0 255.255.255.0
ZXR10(config-router)#neighbor 192.208.10.5 remote-as 300
```

BGP Configuration Example

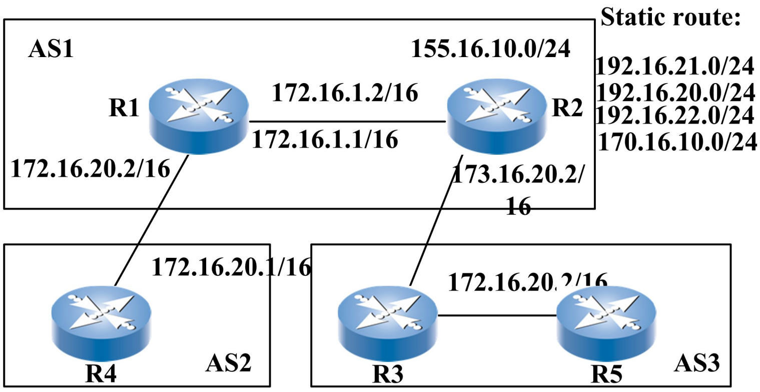
The following is a BGP comprehensive example. It involves the actual applications of such BGP functions as route aggregation and static route redistribution. This is shown in Figure 23.

R4 establishes the EBGP with the R1. R1 establishes the IBGP with R2. R2 establishes the multi-hop EBGP with tR5.

Suppose that R4 has four static routes marked at the top right corner of the Figure 23. In R4 configuration, only aggregate and advertise the network segment 192.16.0.0/16 and forbid advertising the network segment 170.16.10.0/24 outside by the BGP through the route figure.

EBGP multi-hop relationship is established between R2 and R5 through R3. At the moment, ensure that the addresses on which to establish adjacency can be interconnected in the two routers. This is shown in Figure 23.

FIGURE 23 BGP CONFIGURATION



R4 configuration:

```
ZXR10_R4(config)#route bgp 2
ZXR10_R4(config-router)#redistribute static
ZXR10_R4(config-router)#neighbor 172.16.20.2 remote-as 1
ZXR10_R4(config-router)#aggregate-address 192.16.0.0 255.255.0.0
count 0 as-set summary-only
ZXR10_R4(config-router)#neighbor 172.16.20.2 route-map torouter1
 out
ZXR10_R4(config-router)#exit
ZXR10_R4(config)#acl standard number 1
ZXR10_R4(config-std-acl)#rule 1 permit 172.16.10.0 0.0.0.255
ZXR10_R4(config-std-acl)#exit
ZXR10_R4(config)#route-map torouter1 deny 10
ZXR10_R4(config-route-map)#match ip address 1
ZXR10_R4(config-route-map)#exit
ZXR10_R4(config)#route-map torouter1 permit 20
```

R1 configuration:

```
ZXR10_R1(config)#route bgp 1
ZXR10_R1(config-router)#no synchronization
ZXR10_R1(config-router)#neighbor 172.16.1.2  remote-as 1
ZXR10_R1(config-router)#neighbor 172.16.1.2  next-hop-self
ZXR10_R1(config-router)#neighbor 172.16.20.1  remote-as 2
```

R2 configuration:

```
ZXR10_R2(config)#ip route 183.16.0.0 255.255.0.0
 172.16.20.2
ZXR10_R2(config)#route bgp 1
ZXR10_R2(config-router)#neighbor 172.16.1.1 remote-as 1
ZXR10_R2(config-router)#neighbor 172.16.1.1 next-hop-self
ZXR10_R2(config-router)#neighbor 183.16.20.2 remote-as 3
ZXR10_R2(config-router)#neighbor 183.16.20.2 ebgp-multihop 2
ZXR10_R2(config-router)#neighbor 183.16.20.2 route-map
 torouter5 in
ZXR10_R2(config-router)#exit
ZXR10_R2(config)#acl standard number 1
ZXR10_R2(config-std-acl)#rule 1 permit 155.16.10.0 0.0.0.255
ZXR10_R2(config-std-acl)#exit
ZXR10_R2(config)#route-map torouter5 deny 10
ZXR10_R2(config-route-map)#match ip address 1
ZXR10_R2(config-route-map)#exit
ZXR10_R2(config)#route-map torouter5 permit 20
```

R5 configuration:

```
ZXR10_R5(config)#ip route 173.16.0.0 255.255.0.0
183.16.20.2
ZXR10_R5(config)#route bgp 3
ZXR10_R5(config-router)#neighbor 173.16.20.2 remote-as 1
ZXR10_R5(config-router)#neighbor 173.16.20.2 ebgp-multihop 2
```

BGP Maintenance and Diagnosis

Step	Command	Function
1	ZXR10(config)#**show ip bgp protocol**	This displays the configuration information of the BGP module.
2	ZXR10(config)#**show ip bgp neighbor** [**in**|**out**]<*ip-address*>	This displays the BGP adjacency and the current neighbor state.
3	ZXR10(config)#**show ip bgp**[**network** <*ip-address*>[**mask** <*net-mask*>]]	This displays the BGP routing table entries.
4	ZXR10(config)#**show ip bgp summary**	This displays the connection state of all BGP neighbors.
5	ZXR10(config)#**show ip route** [<*ip-address*><*net-mask*>] **bgp**	This displays routing table and checks if BGP in the route table.
6	ZXR10(config)#**show ip forwarding subnetrt** <*ip-address*><*net-mask*>	This displays hardware driving routing table.
7	ZXR10#**debug ip bgp in**	This traces and show the notification packet sent by the BGP.
8	ZXR10#**debug ip bgp out**	This tracks and display the notification packet sent by the BGP.
9	ZXR10#**debug ip bgp events**	This traces and display the transition of state machine connected to the BGP.

Example This example is to trace the state transition of the BGP with the **debug ip bgp events** command.

```
ZXR10#debug ip bgp events
BGP events debugging is on
ZXR10#
04:10:07: BGP: 192.168.1.2 reset due to Erroneous BGP
Open received
04:10:07: BGP: 192.168.1.2 went from Connect to Idle
04:10:08: BGP: 192.168.1.2 went from Idle to Connect
04:10:13: BGP: 192.168.1.2 went from Connect to OpenSent
04:10:13: BGP: 192.168.1.2 went from OpenSent to OpenConfirm
04:10:13: BGP: 192.168.1.2 went from OpenConfirm to
 Established
ZXR10#
```

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Chapter 6

Multicast Routing Configuration

Table of Contents

Multicast Overview 65
Configuring Public Multicast 69
Configuring IGMP Version 69
Configuring PIM-SM 72
Configuring MSDP...76
Configuring PIM-DM 78
Configuring PIM-SNOOPING 78
Multicast Configuration Example 78
Multicast Maintenance and Diagnosis...................................80

Multicast Overview

Multicast is a point-to-multipoint or multipoint-to-multipoint communication mode. Multiple receivers can synchronously receive the same message from one source. The applications based on multicast include video conference, distance learning and software distribution.

Multicast protocol consists of the group member management protocol and the multicast routing protocol. The group member management protocol is applicable to management of the joining or leaving of multicast group members. Multicast routing protocol is responsible for the establishment of a multicast tree by exchanging information between routers. Multicast routing protocol can be divided into the intra-area multicast routing protocol and the inter-area multicast routing protocol.

ZXR10 5900/5200 supports the following protocols:

- IGMPInternet Group Management Protocol
- PIM-SMProtocol Independent Multicast Sparse Mode
- MSDPMulticast Source Discovery Protocol
- PIM-DMProtocol Independent Multicast Dense Mode

Multicast Address

In a multicast network the sender sends a packet to multiple receivers in a multicast mode. In this situation the sender is called the multicast source. Multiple receivers for the same packet are identified by same ID. This is called the multicast group address. In the IP address allocation scheme class D IP address is 224.0.0.0-239.255.255.255. It is just a multicast address. 224.0.0.0-224.0.0.255 and 239.0.0.0-239.255.255.255 are used for the purpose of research and management.

IGMP

IGMP is a protocol that is used to help the multicast router to get information of multicast group members which are running between mainframe and multicast router.

Multicast router periodically sends query messages of group members to all mainframes in order to know which specific group members exist in the connected networks. The mainframe returns a report message of group members, reporting the multicast group which they belong to. A mainframe immediately sends report messages of group members instead of awaiting a query when it joins a new group.

When the mainframe leaves the group, it sends a message indicating its purpose to the multicast router. The multicast router will immediately query whether there are still group members running in the group. If so, the multicast router will continue to forward data. If not, it will not forward data any longer.

In the current actual applications there are two versions: IGMP V1 and IGMP V2.

IGMP V2 has more enhanced features than the IGMP V1. It finishes exchanging information between the mainframe and the routers by means of four types of messages.

1. Group member query
2. V2 member report
3. Leave report
4. V1 member report

V1 member report is used for the compatibility with the IGMP V1.

Multicast Tree

In a multicast communication router the possession of multicast source, receiver and of multicast packet path is essential. For path selection, the most common method is to construct tree routes. Tree route has the following two advantages:

1. The packet reaches different receivers along branches in a parallel mode.

2. The packet copy only occurs in the branch position which makes the sent packets over network minimum.

A multicast tree is a set, which is composed of a series of input interfaces and output interfaces of routes. It determines only one forwarding path between both the subnet where the multicast source lies and the subnets containing group members.

There are two basic methods to construct multicast trees: the source-based multicast tree and the multicast rendezvous point tree (RPT).

1. Source-Based Multicast Tree

   The source-based multicast tree is also called source shortest path tree. It constructs a spanning tree toward all receivers for each source. The spanning tree with the subnet of the source as a root node extends to the subnet where receivers exist. A multicast group may have multiple multicast sources.

   Each source or each pair (S, G) has a corresponding multicast tree.

   Method to construct the source-based multicast trees is the reverse path forwarding (RPF). Each router can find the shortest path toward the source and the corresponding output interface according to a unicast route. When receiving a multicast packet, a router checks whether the input interface receiving it is the output interface of the shortest unicast path toward the source itself. If so, the router copies and forwards the packet to other interfaces. If not, the router discards the multicast packet.

   The input interface receiving the multicast packet in the router is called the father link. The output interface sending the multicast packet is called the sub-link.

2. Multicast Rendezvous Point Tree

   The multicast rendezvous point tree constructs a multicast tree for each multicast group. This tree is shared by all members. Namely, the (*, G) use commonly a preceding multicast tree but not construct a tree for each pair (S, G). Each device wanting to receive the multicast packet of the group must explicitly join the RPT.

   The multicast RPT uses a router or a group of routers as the center of the multicast tree. All source direction receivers send the packet to the center in a unicast mode, and start to forward from the center along the multicast RPT tree in a multicast mode.

PIM-SM

PIM-SM sends multicast packet by using the multicast RPT. A multicast RPT has a center point that is responsible for sending packets to the ports of all sources of a multicast group. Send ports of each source sends packets to the center point along the shortest path and distribute packets to receiving ports. The group center point of the PIM-SM is called Rendezvous Point (RP). A network may have multiple RPs, whereas a multicast group has only one RP.

A router can determine the location of the RP by three methods. The first method is the manual static configuration RP running routers of the PIM-SM. The other two methods are dynamic. They are determined according to the PIM-SM version adopted by the network. The PIM-SM V 1 adopts the Auto-RP whereas PIM-SM V2 adopts Candidate-RP advertising mode. The Candidate-RP with higher priority is the formal RP.

PIM-SM V2 manually configures some routers running PIM-SM as Candidate-BSR (BootStrap Router) and selects the Candidate-BSR as the formal BSR. The BSR is responsible for collecting Candidate-RP information of multicast routers. If finding some Candidate-RP, the BSR advertises them to all PIM routers in the PIM area. These PIM routers according to the similar Hash rules select one with higher priority as the formal RP from the same candidate-RP set. The candidate-RP is manually configured.

The routers running PIM-SM find them and maintain the adjacency by exchanging the Hello messages. In the Multi-access network the Hello message also contains the priority information of the router. According to the parameter, select the Designate Router (DR).

Multicast source or the first hop router (DR directly connected with the source) encapsulates the packet in a registration message and sends it to the RP through the unicast router. When receiving the registration message the RP decapsulates and takes out the packet and sends it to the receiver of the group along the RPT.

Each mainframe acting as the receiver joins the multicast group through the member report message of the IGMP. The last hop router (or the DR in the multi-access network) sends the received joining message to the RP for registration level by level. Intermediary router checks whether to have the router of the group after receiving the joining message. If so, the intermediary router adds the request router of the downstream to the RPT as a branch. If not, it continues to send the joining message to the RP.

When the RP or the multicast router is directly connected with the receiver they can switch to the source-based shortest path tree from the RPT. When the RP receives registration messages sent from a new multicast source, the RP returns a joining message to the DR directly connected with the multicast source. Thus, the shortest path tree from the source to the RP is established.

A DR or router directly connected with the multicast members receives the first multicast packet from the multicast or the received packet reaches a threshold. They can switch to the source-based shortest path tree from the RPT. Once switchover occurs, the router will send a prune message to the neighbor of the upstream and require leaving the RPT.

MSDP

MSDP is a mechanism that allows RPs in each PIM-SM domain to share information about active sources. Each RP knows the receivers within the local domain. When RPs has learned information about active sources in remote domains, they can transfer the information to receivers in local domain. Thus, multicast packets can be forwarded among domains.

MSDP speaker in a PIM-SM domain establishes MSDP peering session with MSDP peers in other domains through TCP connection. When MSDP speaker has learnt a new multicast source (through the PIM register mechanism) in local domain, it creates a Source-Active message and sends it to all the MSDP peers.

Each MSDP peer that receives the message uses peer-RPF check and only the SA message received on correct interface is forwarded, discarding the others. When an MSDP peer which is also an RP for its own domain receives a new SA message and the outgoing interface list in (*, G) entry is non-empty, that is, there are receivers within the domain, RP creates a (S, G) state for multicast source and adds this entry to the shortest-path tree of the source.

In addition, each MSDP peer saves the received SA messages in a cache, thus establishing a SA cache table. If the RP in a PIM-SM domain receives a new PIM join message for multicast group G, the RP searches its own SA cache table to get all the active multicast sources immediately, thus generating the corresponding (S, G) Join message.

PIM-SNOOPING

PIM Snooping obtains the multicast routing port by snooping the HELLO and JOIN/PRUNE messages of the multicast protocol and forwards the multicast data as well as reduces network traffic.

Configuring Public Multicast

Step	Command	Function
1	`ZXR10(config)#`**ip multicast-routing**	This boots the IP multicast route.
2	`ZXR10#`**clear ip mroute** [**group-address** <*group-address*>][**source-address** <*source-address*>]	This deletes the IP multicast routing table.

Configuring IGMP Version

ZXR10 5900/5200 IGMP function is based on PIM interface. All interfaces enabling PIM enables IGMP function automatically.

Configuring IGMP Version

At present the IGMP has the V1 and the V2. Default value is V2. For security, a router requires router requires the Network Element

(NE) in the same network segment to be the IGMP V1 or the IGMP V2.

For the configuration of IGMP version number of the interface, use the following command.

Command	**Function**
ZXR10(config-if-vlanX)#**ip igmp version** <*version*>	This configures IGMP version.

Configuring an IGMP Group

1. To configure group range that allows IGMP to join, use the following command.

Command	**Function**
ZXR10(config-if-vlanX)#**ip igmp access-group**<*acl-number*>	This configures group range that allows IGMP to join.

   This example shows running of IGMP on the interface. The interface receives all multicast groups by default and sets the receiving group range on the interface. When the joining request from the mainframe does not belong to the range discard the joining request.

   Only receive the group 239.10.10.10 on the Vlanl interface.

```
ZXR10(config)#acl standard number 10
ZXR10(config-std-acl)#rule 1 permit 239.10.10.10 0.0.0.0
ZXR10(config-std-acl)#exit
ZXR10(config)#interface vlan 1
ZXR10(config-if-vlan1)#ip igmp access-group 10
```

2. To configure the group range permitting the IGMP to leave right away, use the following command.

Command	**Function**
ZXR10(config-if-vlanX)#**ip igmp immediate-leave** [**group-list** <*acl-number*>]	This configures the group range permitting the IGMP to leave right away.

   Upon receiving the message of the IGMP leaving or not receiving the Report message within (last member query intervalx2+1) seconds then the group members leaves.

   In the below configuration the group is permitted 239.10.10.10 to leave right away on the Vlanl interface.

```
ZXR10(config)#acl standard number 10
ZXR10(config-std-acl)#rule 1 permit 239.10.10.10 0.0.0.0
ZXR10(config-std-acl)#exit
ZXR10(config)#interface vlan 1
ZXR10(config-if-vlan1)#ip igmp immediate-leave group-list 10
```

3. To configure the static group member on the IGMP interface, use the following command.

Command	Function
ZXR10(config-if-vlanX)#**ip igmp static-group**<*group-address*>	This configures the static group member on the IGMP interface.

Above configuration statically binds the group address to an interface. Supposing there are always members of the group on the interface.

To configure the static group 239.10.10.10 on the Vlanl interface is shown below:

```
ZXR10(config)#interface vlan 1
ZXR10(config-if-vlan1)#ip igmp static-group 239.10.10.10
```

Configuring IGMP Timer

IGMP boots on the multicast router interface that is connected with a shared network segment. Select the optimum one as the Querier of the network segment which is responsible for sending the query message to obtain the information of the group members.

After sending query messages, the Querier will wait for the member report of the receiving mainframe for some time. The duration is the Max Response Time value carried when sending query messages. The default value is 10 seconds.

Upon receiving query messages the mainframe member on the network segment will reduce a random deviation value based on the maximum response time. It will take the result as its own response time.

During this period the mainframe member will cancel the receiving reports of other mainframe. If the mainframe report is not cancelled then mainframe member will send the mainframe report at the right time. Therefore, prolonging the max response time will accordingly increase the waiting chances for the group member of the network segment. The mainframe member will reduce the burst rate of multiple mainframe reports on the network segment.

Step	Command	Function
1	ZXR10(config-if-vlanX)#**ip igmp query-interval**<*seconds*>	This configures IGMP query time interval.
2	ZXR10(config-if-vlanX)#**ip igmp querier-timeout**<*seconds*>	This configures the IGMP querier timeout length.
3	ZXR10(config-if-vlanX)#**ip igmp query-max-response-time**<*seconds*>	This configures the maximum response time value carried by query messages when the IGMP sends query messages.
4	ZXR10(config-if-vlanX)#**ip igmp last-member-query-interval**<*seconds*>	This configures the query interval of a specific group of the IGMP.

Configuring ssm-mapping

To configure ssm-mapping and take received igmp v2 user as v3 user, use the following command.

Step	Command	Function
1	ZXR10(config)#**ip igmp snooping ssm-mapping**	This enables ssm-mapping function globally.
2	ZXR10(config)#**ip igmp snooping ssm-mapping-rule** *<group address><source address>*	This configures ssm-mapping rule.
3	ZXR10(config)#**ip igmp snooping clear-ssm-mapping**	This clears all configured ssm-mapping rules.

Configuring PIM-SM

Booting PIM-SM

Command	Function
ZXR10(config)#**router pimsm**	This boots PIM-SM.

Configuring Static RP Address

Configuration should be done of a static RP for a multiple specific groups and also configure same static RPs for the group on all PIM-SM multicast routers in the multicast area.

Usually the loopback interface address is used to reduce the network vibration caused by the Up/Down of a physical interface.

After the static RP is configured, it is not necessary to configure the Candidate-RP for the group.

To configure the static RP address, use the following command.

Command	Function
ZXR10(config-router)#**static-rp** *<ip-address>*[**group-list** *<acl-number>*][**priority** *<priority>*]	This configures static RP address.

Example

1. This example shows configuration of static RP 10.1.1.1 for all groups.
```
ZXR10(config-router)#static-rp 10.1.1.1
```
2. Configuration of the static RP 10.1.1.1 for the group 239.132.10.100 is shown below.
```
ZXR10(config-router)#static-rp 10.1.1.1 group-list 10
ZXR10(config-router)#exit
```

```
ZXR10(config)#acl standard number 10
ZXR10(config-std-acl)#rule 1 permit 239.132.10.100 0.0.0.0
```

Configuring Candidate-BSR

If the static RP mechanism is not used then every multicast area must be configured with the Candidate-BSR on more than one multicast routers. A BSR should be selected. The BSR sends booting messages to advertise RP information. According to the latest advertising messages, router running the PIM-SM updates the RP state. The bootstrap message send by the BSR is also used to select the formal BSR in the Candidate-BSR.

To configure Candidate-BSR, use the following command

Command	Function
ZXR10(config-router)#**bsr-candidate** <*interface-name*>[<*hash-mask-length*>][<*priority*>]	This configures Candidate-BSR.

The default priority of Candidate-BSR is 0. Candidate-BSR with higher priority becomes formal BSR.

Configure the Candidate-RP

In the PIM-SM, the RP is a root of the multicast RPT. It is responsible for sending the multicast packet to the receiving member of the group in the downstream along the tree. Each multicast group has only one formal RP.

To configure the Candidate-RP, use the following command.

Command	Function
ZXR10(config-router)#**rp-candidate** <*interface-name*>[**group-list** <*acl-number*>][**priority** <*priority*>]	This configures the Candidate-RP.

The default priority of the Candidate-RP is 0. The candidate-RP with greater priority value has smaller priority.

Switching Routers with Directly Connected Receivers

Only the last hop DR and the RP can actively switch to the source shortest path tree. By default, start to switch the source shortest path tree when the RP receives the first registration information. For the last hop DR, configure the switch threshold strategy of the source shortest path tree, with the unicast group as control gran-

ularity. If configuring the switch threshold with infinity, switching does not occur. By default, switch must take place if traffic exists.

Command	Function
ZXR10(config-router)#**spt-threshold infinity** [**group-list** <*access-list-number*>]	This switches routers with directly connected receivers from SPT tree to the RPT

Configuring the Area Border with the Interface PIM

Command	Function
ZXR10(config-if-vlanX)#**ip pim bsr-border**	This configures the area border with the interface PIM.

Bootstrap data packets cannot pass the border in any direction. The command effectively divides a network into different BSR areas. Other PIM packets can pass the area border.

Setting the RP to Filter the Received Register Packet

Command	Function
ZXR10(config-router)#**accept-register**<*acl-number*>	This sets the RP to filter the received Register packet.

Limiting the BSR Message to Advertise to the Candidate-RP

To limit the BSR message to advertise to the Candidate-RP, use the following command

Command	Function
ZXR10(config-router)#**accept-rp** <*acl-number*>	This limits the BSR message to advertise to the Candidate-RP.

Setting DR Priority

Command	Function
ZXR10(config-if-vlanX)#**ip pim dr-priority**<*priority*>	This sets the DR priority.

It is necessary to select a DR in a shared (or Multi-Access) network segment. Router with the highest priority will win the selection. If the priorities are similar, the router with the greatest IP address will be selected.

In the shared network segment connected with the multicast data source only the DR can send the registration information to the RP. In the shared network segment connected with the receiver only the DR can respond to the joining and leaving messages of the IGMP and sends the PIM joining/prune message to the upstream.

The priority of the router is contained in the exchanging Hello message with the neighbor. The default value is 0.

Setting the Sending Interval of the Hello Message

Command	Function
ZXR10(config-if-vlanX)#**ip pim query-interval** <*seconds*>	This sets the sending interval of the Hello message.

Limiting PIM-SM Neighbor

Command	Function
ZXR10(config-if-vlanX)#**ip pim neighbor-filter** <*acl-number*>	This limits some routers to be PIM neighbor.

Example This example shows that the router 10.1.1.1 is limited to be the PIM neighbors on the interface Vlan1.

```
ZXR10(config)#acl standard number 10
ZXR10(config-std-acl)#rule 1 deny 10.1.1.1 0.0.0.0
ZXR10(config-std-acl)#rule 2 permit any
ZXR10(config-router)#exit
ZXR10(config)#interface vlan 1
ZXR10(config-if-vlan1)#ip pim neighbor-filter 10
```

Configuring MSDP

Enabling MSDP

Command	Function
ZXR10(config)#**ip msdp peer** <*peer-address*> **connect-source** <*interface-name*>	This configures an MSDP peer and enables MSDP.

Configuring Default MSDP Peer

Command	Function
ZXR10(config)#**ip msdp default-peer** <*peer-address*>[**list** <*acl-number*>]	This configures default MSDP peer.

When default MSDP peer is configured, the local router accepts all SA messages from the peer.

Configuring an Originating RP

Command	Function
ZXR10(config)#**ip msdp originator-id** <*interface-name*>	This configures an originating RP.

This command generates the MSDP speaker of SA messages. It also uses address of specified interface as the RP address in a SA.

Configuring the MSDP Peer as a Mesh Group Member

Command	Function
ZXR10(config)#**ip msdp mesh-group** <*peer-address*><*mesh-name*>	This configures the MSDP peer as a mesh group member.

A "mesh group" is a group of MSDP speakers. These speakers have fully meshed connectivity.

Clearing Statistics Counter for MSDP Peers

Command	Function
ZXR10#**clear ip msdp statistics** [<*peer-address*>]	This clears statistics counter for MSDP peers.

Clearing Statistics Counter for MSDP Peers

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ZXR10#**clear ip msdp statistics** [<*peer-address*>]	This clears statistics counter for MSDP peers.

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Clearing Statistics Counter for MSDP Peers

Command	Function
ZXR10#**clear ip msdp statistics** [<*peer-address*>]	This clears statistics counter for MSDP peers.

Configuring PIM-DM

Step	Command	Function
1	ZXR10(config)#**router pimdm**	This enables PIM-DM function.
2	ZXR10(config-if)#**ip pim dm**	This adds an interface that runs PIM-DM.

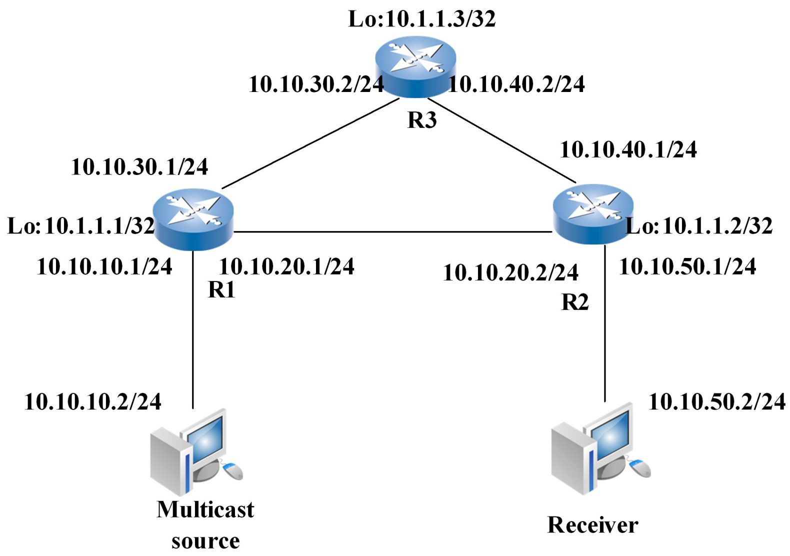
Configuring PIM-SNOOPING

Step	Command	Function
1	ZXR10(config)#**ip pim snooping**	This enables PIM-SNOOPING function.
2	ZXR10(config-vlanX)#**pim snooping**	This enables PIM-SNOOPING function in VLAN.

Multicast Configuration Example

PIM-SM configuration and network topology is shown in Figure 24.

FIGURE 24 MULTICAST CONFIGURATION



R1 configuration:

```
ZXR10_R1(config)#ip multicast-routing
ZXR10_R1(config)#interface loopback1
ZXR10_R1(config-loopback1)#ip address  10.1.1.1 255.255.255.255
ZXR10_R1(config)#router pimsm
ZXR10_R1(config-router)#rp-candidate loopback1 priority 10
ZXR10_R1(config-router)#bsr-candidate loopback1 10 10
ZXR10_R1(config)#interface vlan1
ZXR10_R1(config-if-vlan1)#ip address  10.10.10.1 255.255.255.0
ZXR10_R1(config-if-vlan1)#ip pim sm
ZXR10_R1(config)#interface vlan2
ZXR10_R1(config-if-vlan2)#ip address  10.10.20.1 255.255.255.0
ZXR10_R1(config-if-vlan2)#ip pim sm
ZXR10_R1(config)#interface vlan3
ZXR10_R1(config-if-vlan3)#ip address  10.10.30.1 255.255.255.0
ZXR10_R1(config-if-vlan3)#ip pim sm
ZXR10_R1(config)#router ospf 1
ZXR10_R1(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
```

R2 configuration:

```
ZXR10_R2(config)#ip multicast-routing
ZXR10_R2(config)#interface loopback1
ZXR10_R2(config-loopback1)#ip address  10.1.1.2 255.255.255.255
ZXR10_R2(config)#router pimsm
ZXR10_R2(config-router)#rp-candidate loopback1 priority 20
ZXR10_R2(config-router)#bsr-candidate loopback1 10 20
ZXR10_R2(config)#interface vlan1
ZXR10_R2(config-if-vlan1)#ip address  10.10.20.2 255.255.255.0
ZXR10_R2(config-if-vlan1)#ip pim sm
ZXR10_R2(config)#interface vlan2
ZXR10_R2(config-if-vlan2)#ip address  10.10.40.1 255.255.255.0
ZXR10_R2(config-if-vlan2)#ip pim sm
ZXR10_R2(config)#interface vlan3
ZXR10_R2(config-if-vlan3)#ip address  10.10.50.1 255.255.255.0
ZXR10_R2(config-if-vlan3)#ip igmp access-group 10
ZXR10_R2(config)#router ospf 1
ZXR10_R2(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
```

R3 configuration:

```
ZXR10_R3(config)#ip multicast-routing
ZXR10_R3(config)#interface loopback1
ZXR10_R3(config-loopback1)#ip address  10.1.1.3 255.255.255.255
ZXR10_R3(config)#router pimsm
```

```
ZXR10_R3(config-router)#rp-candidate loopback1 priority 30
ZXR10_R3(config-router)#bsr-candidate loopback1 10 30
ZXR10_R3(config)#interface vlan1
ZXR10_R3(config-if-vlan1)#ip address  10.10.30.2 255.255.255.0
ZXR10_R3(config-if-vlan1)#ip pim sm
ZXR10_R3(config)#interface vlan2
ZXR10_R3(config-if-vlan2)#ip address  10.10.40.2 255.255.255.0
ZXR10_R3(config-if-vlan2)#ip pim sm
ZXR10_R3(config)#router ospf 1
ZXR10_R3(config-router)#network 10.0.0.0 0.0.0.255 area 0.0.0.0
```

Multicast Maintenance and Diagnosis

Common View Command

1. To view the IP multicast routing table, use the following command.

Command	**Function**
ZXR10#**show ip mroute** [**group** <*group-address*>][**source** <*source-address*>][**summary**]	This views the IP multicast routing table.

This shows the contents of the current IP multicast routing table.

```
ZXR10#show ip mroute
IP Multicast Routing Table
Flags:D -Dense,S -Sparse,C -Connected,L -Local,P -Pruned
      R -RP-bit set,F -Register flag,T -SPT-bit set,J -Join SPT,
      M - MSDP created entry,N -No Used,U -Up Send,
      A - Advertised via MSDP,X -Proxy Join Timer Running,
      * -Assert flag
Statistic: Receive packet count/Send packet count
Timers:Uptime/Expires
Interface state:Interface,Next-Hop or VCD,State/Mode

(*, 229.3.3.16), 00:00:01/00:03:34, RP 5.5.5.6 , 0/0, flags: SP
  Incoming interface: vlan5, RPF nbr 5.5.5.6
  Outgoing interface list: NULL
(100.1.1.100, 229.3.3.16), 00:00:01/00:03:34 , 0/0, flags: UN
  Incoming interface: vlan4, RPF nbr 4.4.4.5
  Outgoing interface list:
    vlan6, Forward/Sparse, 00:00:01/00:03:29
```

2. To show multicast forwarding entries, use the following command.

Command	**Function**
ZXR10#**show ip mforwarding** [**device** <*device-number*>] **group-address** <*group-address*>[**source-address** <*source-address*>]	This shows multicast forwarding entries. If the command does not carry source address options, show (*, G) multicast forwarding entries. If carrying source address options, show (S, G) multicast forwarding entries.

This shows the multicast forwarding entries.

```
ZXR10#show ip mforwarding group-address 229.3.3.16
IP Forwarding Multicast Routing Table
Flags: N -No Used,U -Up Send,L -Limit upSend,A - Assert send

(*, 229.3.3.16), Flags:, HitFlag:0, Incoming interface: Null,
 LastSrcIp: 0.0.0.0
 Outgoing vlan interface list: NULL

 L2bitmap:0x0000000000000000 L3bitmap:0x0000000000000000

(100.1.1.100, 229.3.3.16), Flags:, HitFlag:0,
 Incoming interface: vlan4 19/3, LastSrcIp: 0.0.0.0
 Outgoing vlan interface list: NULL

 L2bitmap:0x4000000000000008 L3bitmap:0x0000000000000000
```

3. To show the multicast reverse path forwarding message, use the following command.

Command	Function
ZXR10(config)#**show ip rpf** <*source-address*>	This shows the multicast reverse path forwarding message.

4. To view the PIM-SM multicast routing table, use the following command.

Command	Function
ZXR10(config)#**show ip pimsm mroute** [**group** <*group-address*>][**source** <*source-address*>][**summary**]	This views the PIM-SM multicast routing table.

Viewing IGMP Information Commands

1. To view the IGMP configuration on the interface, use the following command.

Command	Function
ZXR10#**show ip igmp interface**[<*interface-name*>]	This views the IGMP configuration on the interface.

This shows the IGMP configuration information of the Vlan4 interface.

```
ZXR10#show ip igmp interface vlan4
vlan4
  Internet address is 4.4.4.4, subnet mask is 255.255.255.0
  IGMP is enabled on interface
  Current IGMP version is 2
  IGMP query interval is 125 seconds
  IGMP last member query interval is 1 seconds
  IGMP query max response time is 10 seconds
  IGMP querier timeout period is 251 seconds
  IGMP querier is 4.4.4.4, never expire
  Inbound IGMP access group is not set
  IGMP immediate leave control is not set
```

2. To view the joining information of the IGMP group on the interface, use the following command.

Command	Function
ZXR10#**show ip igmp groups**[<*interface-name*>]	This views the joining information of the IGMP group on the interface.

This shows the group member information on the Vlan1 interface.

```
ZXR10#show ip igmp groups
IGMP Connected Group Membership
Group addr      Interface       Present      Expire      Last Reporter
224.1.1.1       vlan4            00:00:48     never       4.4.4.4
```

Viewing PIM-SM Information Commands

1. To view the BootStrap Router (BSR) information, use the following command.

Command	Function
ZXR10#**show ip pim bsr**	This views the BootStrap Router (BSR) information.

This shows BSR information.

```
ZXR10#show ip pim bsr
BSR address: 6.6.6.6
Uptime: 00:00:11, BSR Priority :0, Hash mask length:30
Expires:00:00:49
This system is a candidate BSR
  candidate BSR address: 6.6.6.6,priority: 0,hash mask length: 30
This System is Candidate_RP:
  candidate RP address: 6.6.6.6(vlan6),priority:192
```

2. To view the RP set information advertised by the BSP, use the following command.

Command	Function
ZXR10#**show ip pim rp mapping**	This views the RP set information advertised by the BSP.

This shows the RP set information advertised by the BSR.

```
ZXR10#show ip pim rp mapping
Group(s) 224.0.0.0/4
  RP 5.5.5.6   static, Priority :192
  RP 6.6.6.6  , :v2, Priority :192
   BSR: 6.6.6.6  ,  via bootstrap
         Uptime: 00:00:14, expires: 00:02:16
```

3. To show the RP information selected by the given multicast group, use the following command.

Command	Function
ZXR10#**show ip pim rp hash** <*group-address*>	This shows the RP information selected by the given multicast group.

This shows the RP information selected by the group 224.1.1.1.

```
ZXR10#show ip pim rp ha 224.1.1.1
```

```
rp address:5.5.5.6   static
```

4. To view the configuration of the PIM-SM interface, use the following command.

Command	Function
ZXR10#**show ip pimsm interface**[<*interface-name*>]	This views the configuration of the PIM-SM interface.

This shows the configuration of the PIM-SM interface.

```
ZXR10#show ip pimsm interface
Address    Interface     State Nbr   Query DR          DR
                                     Count Intvl     Priority
4.4.4.4    vlan4         Up     0    30    4.4.4.4    1
5.5.5.5    vlan5         Up     0    30    5.5.5.5    1
6.6.6.6    vlan6         Up     0    30    6.6.6.6    1
0.0.0.0    vlan100       Down   0    30    0.0.0.0    1
```

5. To view the neighbors of the PIM-SM interface, use the following command.

Command	Function
ZXR10#**show ip pimsm neighbor**[<*interface-name*>]	This views the neighbors of the PIM-SM interface.

This shows the neighbors of the PIM-SM interface.

```
ZXR10#show ip pimsm neighbor
Neighbor AddressInterface  DR Prio  Uptime    Expires
131.1.1.91       vlan4     30000    00:19:34  00:01:29
22.22.22.43      vlan5      1       03:21:25  00:01:16
```

6. To trace the related information of the PIM-SM interface, use the following command.

Command	Function
ZXR10#**debug ip pimsm**	This traces the related information of the PIM-SM interface.

This shows related information of the PIM-SM interface.

```
ZXR10#debug ip pimsm
  PIMSM debugging is on
00:04:11 PIMSM: Received multicast data packet
(5.1.1.2, 224.1.1.1) from vlan1
00:04:11 PIMSM: Start creating (*,224.1.1.1)entry ...
00:04:11 PIMSM: (*,224.1.1.1)entry is created successfully
00:04:11 PIMSM: Start creating (5.1.1.2,224.1.1.1)entry ...
```

Viewing PIM-DM Information Commands

Step	Command	Function
1	ZXR10#**show ip pimdm interface** [<*interface-name*>]	This views configured PIM-DM interface status.

Step	Command	Function
2	ZXR10#**show ip pimdm neighbor** [<*interface-name*>]	This views PIM-DM interface status.
3	ZXR10#**show ip pimdm mroute** [[**group** <*group-address*>[**source** <*source-address*>]]|[**summary**]]	This views PIM-DM multicast routing table content.

Parameter	Description
group <*group-address*>	multicast group address, in dotted decimal mode
source <*source-address*>	source addressin dotted decimal mode
summary	brief

Viewing MSDP Commands

1. To view SA message statistics, use the following command.

Command	Function
ZXR10#**show ip msdp count**	This views SA message statistics.

2. To view MSDP neighbor detailed information, use the following command.

Command	Function
ZXR10#**show ip msdp peer** [<*peer-address*>]	This views MSDP neighbor detailed information.

This shows MSDP neighbor detailed information.

```
ZXR10(config)#show ip msdp peer
MSDP Peer 11.1.1.1
Description:
  Connection status:
    State: Down, Resets: 0, Connection source: vlan4 (4.4.4.4)
    Uptime(Downtime): 00:00:04, Messages sent/received: 0/0
    Connection and counters cleared 00:00:04 ago
  SA Filtering:
    Input (S,G) filter: none
    Output (S,G) filter: none
  Peer ttl threshold: 0
  SAs learned from this peer: 0
```

3. To view S and G status from each MSDP neighbor, use the following command.

Command	Function
ZXR10#**show ip msdp sa-cache** [<*group-address*>[<*source-address*>]]	This views S and G status from each MSDP neighbor.

This views S and G status from each MSDP neighbor.

```
ZXR10#show ip msdp sa-cache
```

```
MSDP Source-Active Cache - 4 entries
(101.101.101.101, 224.1.1.1), RP 49.4.4.4, 00:21:45/ 00:05:57
(101.101.101.101, 224.1.1.2), RP 49.4.4.4, 00:21:45/ 00:05:57
(101.101.101.101, 226.1.1.1), RP 50.4.4.4, 00:09:04/ 00:04:57
(101.101.101.101, 226.1.1.2), RP 50.4.4.4, 00:09:04/ 00:04:57
```

4. To view MSDP neighbor status, use the following command.

Command	Function
ZXR10#**show ip msdp summary**	This views MSDP neighbor status.

This views MSDP neighbor status.

```
ZXR10#show ip msdp summary
MSDP Peer Status Summary
Peer Address   State  Uptime/   Reset  SA
                  Downtime  Count  Count
101.1.1.1    Up   1d10h   9   2
*102.2.2.2    Up   14:24:00  5   20
103.3.3.3    Up   12:36:17  5   10
```

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Chapter 7

Load Balance Configuration

Table of Contents

Load Balance Overview 87
Configuring Load Balance 88
Load Balance Configuration Example 88
Load Balance Maintenance and Diagnosis.............................91

Load Balance Overview

Load balance is to forward data traffic through multiple activated links existing between equipment and to fully take use of the bandwidth of multiple links. Load balance does not mean that data traffic on links have same size.

Data traffic covers incoming traffic and outgoing traffic. Incoming and outgoing traffic load balance is closely related to the route announced outside and learned by the equipment. Incoming traffic load balance is affected by internal route announced outside by the equipment and outgoing traffic load balance is affected by route announced inside by the equipment. They directly affect the installation of multiple route entries reaching the destination in the equipment forwarding table and the control of multiple routes.

ZXR10 5900/5200 adopts route-based load balance to install multiple reachable route entries for a destination address in the forwarding table through configuring the static route, routing protocol and number of routes, thus laying foundation for load balance implementation.

ZXR10 5900/5200 supports per-destination load balance policy. This policy considers the source addresses and destination addresses of packets at the same time and make the packets with the same "source address-destination address" pair pass through the same path (even there are multiple available paths), and the packets with different "source address-destination address" pairs pass through different paths. Such a policy ensures the packets with the same "source address-destination address" pair to arrive in order. Load balance becomes more effective if there are multiple "source address-destination address" pairs in traffic.

Eight different paths can arrive at the destination at most in the ZXR10 5900/5200. Once load balance is configured, interface traffic becomes balanced after a period.

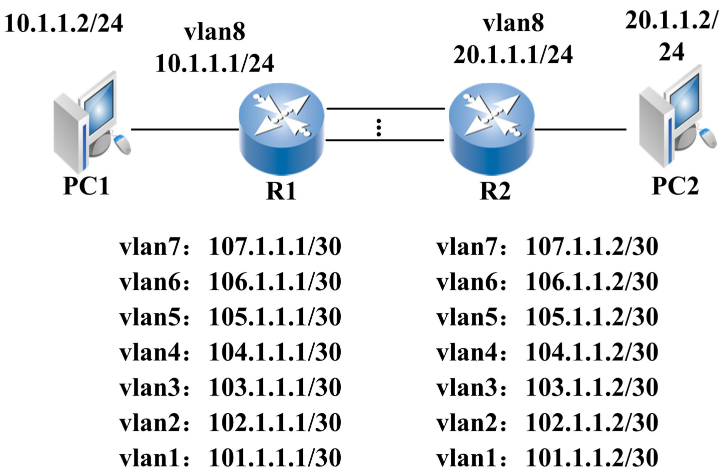
Configuring Load Balance

Step	Command	Function
1	ZXR10(config-router)#**maximum-paths** {<*number*>|**ibgp**<*number*>}	This configures the maximum number of routers. This configures the maximum count of routes in the RIP, OSPF, IS-IS and BGP route configuration mode. The default number of route is 1 and the maximum count is 8.
2	ZXR10(config)#**ip route** <*prefix*><*net-mask*>{<*forwarding-router's-address*>|<*interface-name*>}[<*distance-metric*>][**tag** <*tag*>]	This configures the load balance of static route. This configures multiple static routes to the same destination and supports at most eight routes with different tags. The default value of the tag is 3.

Load Balance Configuration Example

R1 is connected to R2 over seven links. This is shown in Figure 25.

FIGURE 25 LOAD BALANCE CONFIGURATION



Static route and dynamic route protocol OSPF is taken as an example to describe load balance configuration.

Static Routing Load Balance

R1 configuration:

```
ZXR10_R1(config)#interface vlan 1
ZXR10_R1(config-if-vlan1)#ip address 101.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 2
ZXR10_R1(config-if-vlan2)#ip address 102.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 3
ZXR10_R1(config-if-vlan3)#ip address 103.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 4
ZXR10_R1(config-if-vlan4)#ip address 104.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 5
ZXR10_R1(config-if-vlan5)#ip address 105.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 6
ZXR10_R1(config-if-vlan6)#ip address 106.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 7
ZXR10_R1(config-if-vlan7)#ip address 107.1.1.1 255.255.255.252
ZXR10_R1(config)#interface vlan 8
ZXR10_R1(config-if-vlan8)#ip address 10.1.1.1 255.255.255.0

ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 107.1.1.2 1
 tag 157
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 106.1.1.2 1
tag 156
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 105.1.1.2 1
tag 155
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 104.1.1.2 1
tag 154
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 103.1.1.2 1
tag 153
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 102.1.1.2 1
tag 152
ZXR10_R1(config)#ip route 20.1.1.0 255.255.255.0 101.1.1.2 1
tag 151
```

R2 configuration:

```
ZXR10_R2(config)#interface vlan 1
ZXR10_R2(config-if-vlan1)#ip address 101.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 2
ZXR10_R2(config-if-vlan2)#ip address 102.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 3
ZXR10_R2(config-if-vlan3)#ip address 103.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 4
ZXR10_R2(config-if-vlan4)#ip address 104.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 5
ZXR10_R2(config-if-vlan5)#ip address 105.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 6
ZXR10_R2(config-if-vlan6)#ip address 106.1.1.2 255.255.255.252
ZXR10_R2(config)#interface vlan 7
ZXR10_R2(config-if-vlan7)#ip address 107.1.1.3 255.255.255.252
ZXR10_R2(config)#interface vlan 8
ZXR10_R2(config-if-vlan8)#ip address 20.1.1.1 255.255.255.0

ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 107.1.1.1 1
tag 157
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 106.1.1.1 1
tag 156
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 105.1.1.1 1
tag 155
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 104.1.1.1 1
tag 154
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 103.1.1.1 1
tag 153
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 102.1.1.1 1
tag 152
ZXR10_R2(config)#ip route 10.1.1.0 255.255.255.0 101.1.1.1 1
tag 151
```

Seven links between R1 and R2 implement load balance and over these links, the user PC1 and the user PC2 can access each other.

OSPF Load Balance

R1 configuration:

```
ZXR10_R1(config)#router ospf 100
ZXR10_R1(config-router)#network 101.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 102.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 103.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 104.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 105.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 106.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 107.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R1(config-router)#network 10.1.1.0 0.0.0.255 area 0.0.0.0
ZXR10_R1(config-router)#maximum-paths 7
```

R2 configuration:

```
ZXR10_R2(config)#router ospf 100
ZXR10_R2(config-router)#network 101.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 102.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 103.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 104.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 105.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 106.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 107.1.1.0 0.0.0.3 area 0.0.0.0
ZXR10_R2(config-router)#network 20.1.1.0 0.0.0.255 area 0.0.0.0
ZXR10_R2(config-router)#maximum-paths 7
```

BGP Load Balance

R1 configuration:

```
ZXR10_R1(config)#router bgp 100
ZXR10_R1(config-router)# neighbor 101.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 102.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 103.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 104.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 105.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 106.1.1.2 remote-as 200
ZXR10_R1(config-router)# neighbor 107.1.1.2 remote-as 200
ZXR10_R1(config-router)#network 10.1.1.0 255.255.255.0
ZXR10_R1(config-router)#maximum-paths 7
```

R2 configuration:

```
ZXR10_R2(config)#router bgp 200
ZXR10_R2(config-router)# neighbor 101.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 102.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 103.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 104.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 105.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 106.1.1.1 remote-as 100
ZXR10_R2(config-router)# neighbor 107.1.1.1 remote-as 100
ZXR10_R2(config-router)# network 20.1.1.0 255.255.255.0
ZXR10_R2(config-router)#maximum-paths 7
```

Seven links between R1 and R2 implement load balance and over these links, the user PC1 and the user PC2 can access each other.

Load Balance Maintenance and Diagnosis

To configure load balance maintenance and diagnosis, use the following command.

Command	Function
ZXR10#**show ip route** [<*ip-address*>[<*net-mask*>]|<*protocol*>]	This configures load balance maintenance and diagnosis.

This can be seen that seven paths reaching the destination network segment 20.1.1.0/24 on R1 when adopting static route load balance:

```
ZXR10_R1#show ip route 20.1.1.0
IPv4 Routing Table:
  Dest      Mask           Gw     Interface   Owner   pri metric
20.1.1.0  255.255.255.0 107.1.1.1  vlan7     static   1   0
```

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Figures

Figure 1 STATIC ROUTE CONFIGURATION 2
Figure 2 STATIC ROUTE SUMMARY 3
Figure 3 DEFAULT ROUTE CONFIGURATION 4
Figure 4 BASIC RIP CONFIGURATION 11
Figure 5 OSPF ROUTER TYPES 17
Figure 6 BASIC OSPF CONFIGURATION.................................23
Figure 7 MULTI-AREA OSPF CONFIGURATION 24
Figure 8 OSPF VIRTUAL LINK 26
Figure 9 OSPF AUTHENTICATION 27
Figure 10 IS-IS AREAS 35
Figure 11 SINGLE AREA CONFIGURATION 38
Figure 12 MULTIPLE AREA IS-IS CONFIGURATION..................40
Figure 13 BASIC BGP CONFIGURATION 47
Figure 14 BGP ROUTE ADVERTISEMENT...............................48
Figure 15 BGP AGGREGATE ADVERTISEMENT 49
Figure 16 CONFIGURATION OF BGP MULTIHOP 50
Figure 17 FILTERING ROUTES USING NLRI...........................52
Figure 18 LOCAL_PREF ATTRIBUTE 53
Figure 19 MED ATTRIBUTE 55
Figure 20 BGP SYNCHRONIZATION CONFIGURATION..............57
Figure 21 BGP ROUTER REFLECTOR CONFIGURATION.............58
Figure 22 BGP CONFEDERATION CONFIGURATION 60
Figure 23 BGP CONFIGURATION 62
Figure 24 MULTICAST CONFIGURATION 79
Figure 25 LOAD BALANCE CONFIGURATION 88

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Tables

Table 1 CHAPTER SUMMARY i

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Glossary

ASBR - Autonomous System Border Router

BDR - Backup Designate Router

ABR - Area Border Router

DIS - Designate IS IS

CLNS - ConnectionLess Network Sevice

CIDR - Classless Inter-Domain Routing

EBGP - External Border Gateway Protocol

DR - Designate Router

ISO - International Organization for Standardization

IGMP - Internet Group Management Protocol Internet

IGP - Interior Gateway Protocol

LSA - Link State Advertisement

MED - MULTI_EXIT_DISC

NBMA - Non-Broadcast Multiple Access

OSI - Open Systems Interconnection

OSPF - Open Shortest Path First

RIP - Routing Information Protocol

PDU - Protocol Data Unit

SPF - Shortest Path First

VLSM - Variable Length Subnet Mask

SNP - Sequence Num PDU PDU

BSR - Bootstrap Router

IBGP - Interior Border Gateway Protocol

IS-IS - Intermediate System-to-Intermediate System

LSU - Link State Update

MSDP - Multicast Source Discovery Protocol

NSSA - Not-So-Stubby Area

PIM-SM - Protocol Independent Multicast Sparse Mode

RP - Rendezvous Point

AD - Administrative Distance

BGP - Border Gateway Protocol

AS - Autonomous System